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Siphon Spillways in Europe.

By ADOLF LUDIN.*

In the issue of Engineering News for Oct. 13, 1910, p. 398, there was a description of a siphon spillway system which had been constructed in the Champlain branch of the New York State Barge Canal. Many readers of this journal may be interested to learn that in Europe such systems have already been employed for some years and that their capacity has been developed to a considerable degree.

Fig. 1 shows a siphon which was constructed in 1870 at the dam for supplying water to the Saarkohlenkanal, near Mittersheim (Lorraine). The large curved pipe has a diameter of 2 ft. 4 in., and at its bend is connected with a smaller 6 in. pipe fitted with an ejector. As soon as the water rises above its normal level the ejector comes into action and sucks the air from the bend of the large pipe, which fills with water and begins to act as a siphon long before the water has risen above the level of the bend.

The presence of the smaller pipe, which is necessary to set the siphon in operation, forms a weak point in the arrangement since it is liable to be choked by debris, and also is put out of action by frost. Besides, the circular form of the pipe renders it uneconomical in construction and practicable only in pipes of small diameter.

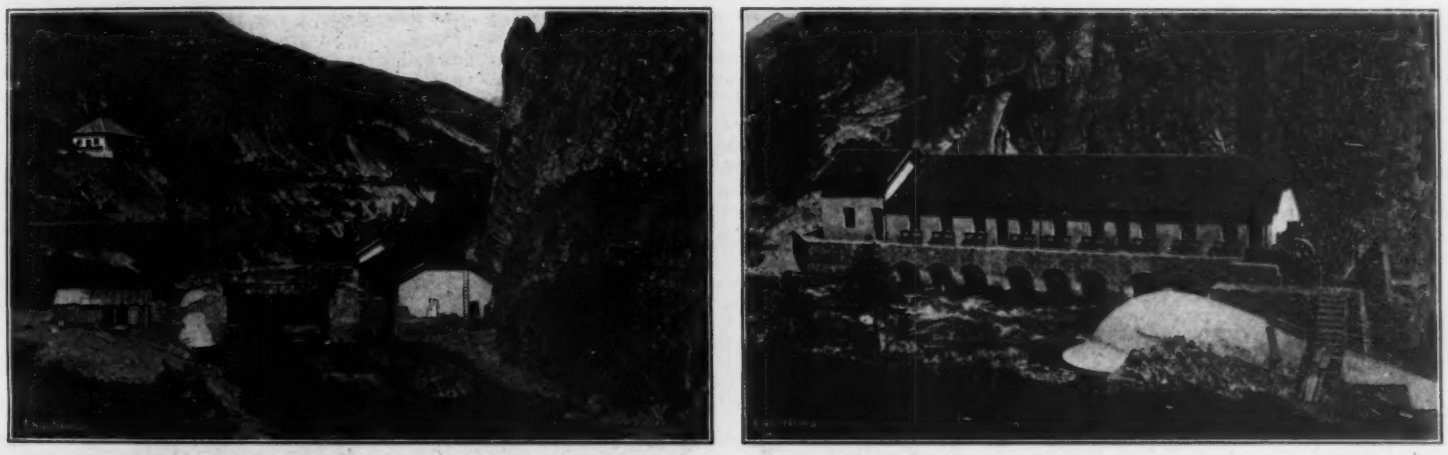
These disadvantages have been avoided in later design. The credit for having constructed the first spillway siphon without ejectors belongs to Mr. J. Heyn, a civil engineer of Stettin. Fig. 2 shows one of Heyn's siphons in use near Rastenburg in East Prussia. It is built of riveted sheet iron and is simply fixed on a floodgate in an irrigation canal. The iron pipe of the siphon has a rectangular cross section of 1⅛ × 10½ ft., and the head of water available is 4¼ ft. The quantity of water discharged is calculated theoretically as $1.5 \times 10.5 \times \sqrt{64 \times 4.25} = 254$ cu. ft. per sec.; in reality only 130 cu. ft. are guaranteed by the contractor, expressing an efficiency of about 50%. However, according to the assurances of both the contractor and the owner, this result is said to have been exceeded.

The action of this siphon depends on the fact that the water, running at the beginning in a small stream along the lower surface of the crest of the siphon draws quickly with it, by its motion, more and more of the air from the upper part of the siphon, and thus the siphon is quickly brought into full activity. As soon as the inflow from above is smaller than the capacity of the siphon the water level sinks below the inlet and the current is broken, while as a precaution against freezing, the water collected in the elbow of the outflow pipe escapes in drops through a small hole provided for the purpose. Since 1904 Mr. Heyn has constructed in North Germany about 12 siphons of this kind, but only of small dimensions, according to the particular circumstances under which the irrigation there has been carried out.

At Mortara, in Northern Italy, Mr. Gregotti has constructed spillway siphons without ejectors almost contemporaneously with Mr. Heyn. He has demonstrated the applicability of their principles under the most varied circumstances, and has perfected their constructional development by the use of reinforced concrete, which is specially suited for the purpose. Fig. 3 shows the type of spillway siphons specially favored by Mr. Gregotti. The mouth *a* of the siphon can be made to dip as deeply as desired into the water, as the starting and termination of the activity of the siphon is controlled by the air pipe *f*. In the event of repairs becoming necessary the space *a* can be closed quickly by the insertion of heavy boards in the grooves *A*, and emptied of water by means of the oblique pipe provided for the purpose. The pool *c* is in this case also emptied as a precaution against freezing.

Of the large and numerous siphon installations constructed by Mr. Gregotti in Italy, the greatest up to the present time is that in the Canal Milani near Verona. This one, shown in the foreground of the view in Fig. 4 is a set of ten units (each as in the section to the left in Fig. 3). The set of outlets, which is to be seen beyond the set of siphons, and which comprises likewise ten units, is also constructed on the aspirator system, only without siphonlike action, and may be closed by means of gates. Each of the siphons measures 14 sq. ft. in cross section and has with a working head of 20 ft. a discharge of 285 cu. ft. per sec., corresponding to an efficiency of 41%. Altogether on one face only 59 ft. in length, 2850 cu. ft. per sec. are discharged, this being the total volume of water employed for the working of the five large turbines of the neighboring power station.

In France siphons of still greater dimensions are being employed. At the dams of the electric generating stations near La Praz and Largentiere, the pipes used have a width of 13 ft., reinforced concrete being employed in the construction. The views on this page show the arrangement of the siphons at Largentiere.* This siphon installation is situated near a movable weir, which is kept closed only in winter, when the water is low, and which can be used to raise the water level about 6½ ft. The purpose of the siphon is to guard against damage by river freshets, which are found to occur here frequently and suddenly, and also when the attendant at the dam has not noticed in time the rising of the river at the end of the winter. The siphon has proved its



VIEWS OF POWER-HOUSE AND SIPHON SPILLWAY AT THE LARGENTIERE (FRANCE) HYDROELECTRIC PLANT.

*Engineer, Sophienstrasse 165, Karlsruhe, Baden.

*These two illustrations and the information concerning the siphons have been kindly provided by Mr. Rudolf Buisson, of Karlsruhe.—A. L.

worth under these circumstances, and the flooding of the weir house, which was formerly not an uncommon occurrence, has now been absolutely prevented. Since the efficiency of this great installation may be estimated to be greater than 50%, by painstaking improvements of the inflow and outflow openings, its capacity is calculated as

$$\frac{\pi\ 13^2}{4}\sqrt{64.5 \times 6.5} = 2{,}700 \text{ cu. ft. per sec.}$$

It is unfortunately impossible for the writer to say who planned the two great siphons at La Praz and Largentiere. The A. G. "Stauwerke" in Zurich, acting under

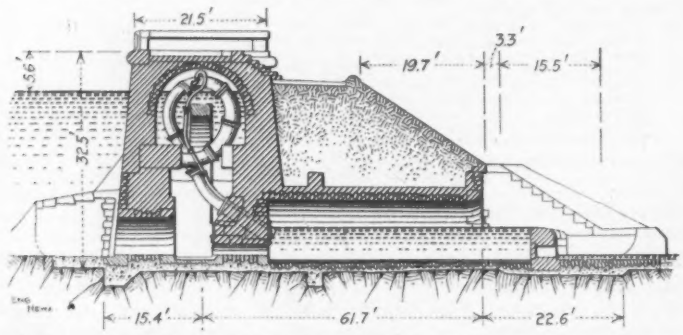


FIG. 1. SIPHON SPILLWAY ON THE SAARKOHLENKANAL, NEAR MITTERSHEIM, LORRAINE, GERMANY.

the advice of its director, Mr. Büchner, has contributed to the further improvement of spillway siphons. However, except in a few cases as at Glattfelden (Canton Thurgau), the firm has not yet had an opportunity of constructing siphons equal in capacity to those just mentioned. One of these siphons, the construction of which is at present in abeyance, is noteworthy on account of the high active head (33 ft.), and also for the fact that it is intended to bring the siphon more quickly into action and to increase its efficiency by admitting the water into the siphon, both by the ordinary inlet and by an opening, just below the crest, in the downflow pipe. The guaranteed capacity of the siphon system, which is to comprise three units, each with a working cross section of 37.5 sq. ft., is 880 cu. ft. per sec. per unit.

Advantages and Difficulties of the Siphon Spillway.

There follows some notes on the capacity and certainty in action of spillway siphons.

First, as regards bringing the siphon into action: This is brought about by the rarefaction of the air in the upper part of the siphon by a small stream of water as it falls over into the downflow pipe. The results of this method have proved, according to the assurances of numerous owners of siphon

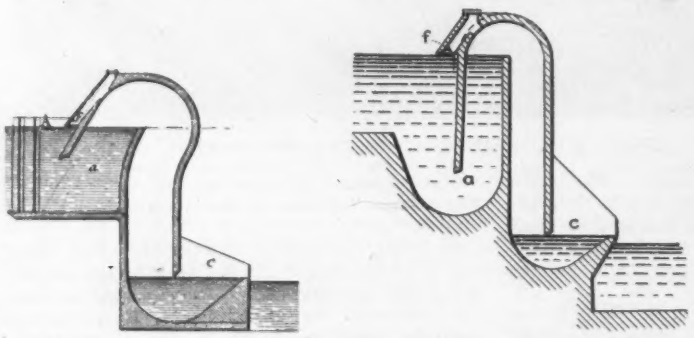


FIG. 3. TYPES OF SIPHON SPILLWAY BUILT BY GREGOTTI IN ITALY.

installations of this kind, favorable even beyond expectations; a rise of 2 to 3 ins. in the water level is in itself sufficient in the case of siphons as great as that constructed near Verona, to bring the siphons into full activity in from one to two minutes.

A second question arises concerning the action of the siphon in cold weather: undoubtedly a fear that its operation may be interrupted by freezing has occasionally prevented the use of such a siphon. With all due recognition of the importance of the question, it must be said that the fears in this respect have been exaggerated, at any rate, as far as the climatic conditions of Germany are concerned. At all events, it is significant that no serious complaint is heard of freezing in the siphon systems installed by Mr. Heyn, though their use has extended to East Prussia. In response to a circular sent by the author of this paper to the owners of siphons constructed by Mr. Heyn, five replies have been received. In answer to the question as to interruptions through freezing, only one writer says that such take place, and then only "extremely seldom." However, information has been received from another owner that from time to time in cold weather it is necessary to break off the ice which forms on the lower edge of the inflow opening, since it makes that limb of the siphon longer than desired and so causes the siphon to come too soon into action. From another source information has been received that interruptions through freezing can take place by reason of the blockage of the small drip hole under the pool in the inflow limb.

Generally speaking, it can well be said that in places where employees are engaged for other purposes in the neighborhood of the siphon, the necessity of attending to it, at the most every few hours, is in no way a serious trouble and introduces no difficulties into the working.

Where the siphon is brought frequently and regularly into use, as is particularly the case on canals for the working of electric generating stations, the danger of freezing is reduced to a minimum, for then the siphon, by reason of its great cross section and the irresistible rush of water through it, readily permits the passage of the larger pieces of ice which are drawn to its mouth. At the same time the formation of ice in the siphon can, with certainty, be prevented by the water passing vigorously through it. According to report, the results given by the siphons at the dams at La Praz and Largentiere, which are situated at a height of about 3,000 ft., are, even in winter, very satisfactory.

Difficulties might arise when the siphons are installed in remote places, as at reservoir dams or distant canal weirs, but even here the danger must not be overestimated. In the case of such dams, for example, it has been established that except when severe cold sets in, the surface sheet of ice does not remain in contact with the wall of the dam, which is kept warm by its own heat and by the heat of the lower strata of water, and which consequently prevents the freezing of the surface water near it. In specially exposed positions or under very severe climatic conditions, the artificial heating of the interior of the siphon might be resorted to, for that principle has recently been applied to the stand pipes of pressure lines. Finally we must not overlook the fact that in the wasteways of reservoir dams the freezing of a siphon in very cold weather is not of great significance, since under such weather conditions the flow of the water is small, and so it seldom happens that there is a surplus supply of water and that the siphon requires to be in working order. In the event of a rise of the river owing to a thaw, the sheet of ice blocking the mouth of the siphon quickly melts and leaves it ready for action. Besides, an attendant is generally stationed at the larger reservoir dams, so that use can be made there of spillway siphons, for their applicability and practicability are indisputable.

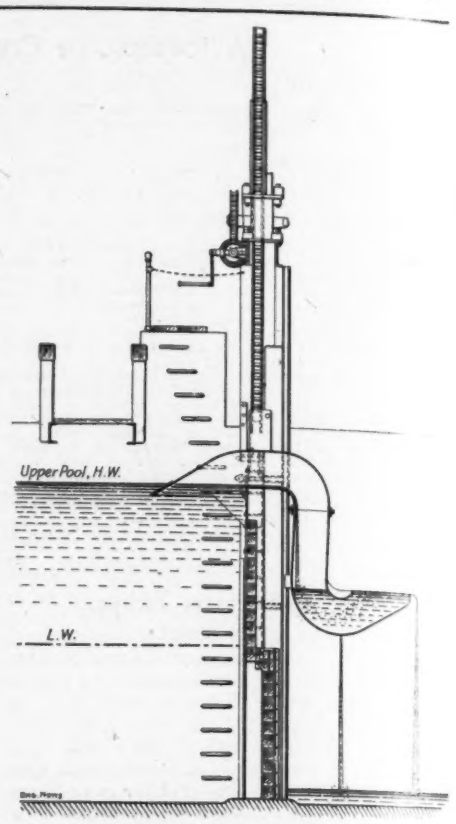


Fig. 2. Siphon Spillway on Irrigation Canal, Near Rastenburg, East Prussia.

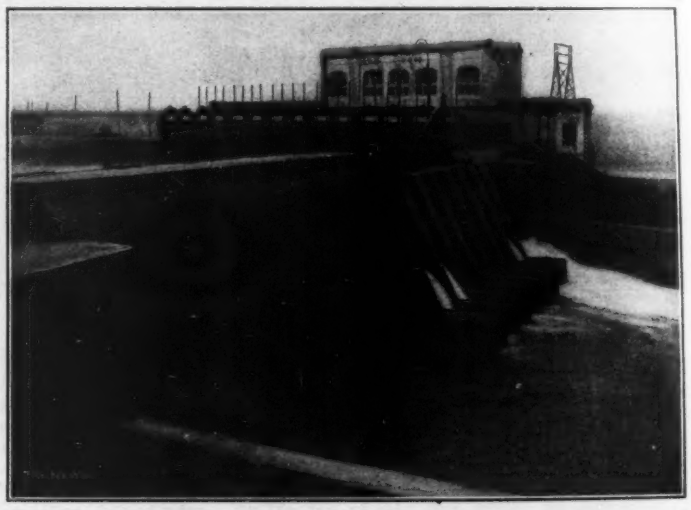


FIG. 4. VIEW OF SET OF TEN SIPHONS ON SPILLWAY OF MILAN CANAL, NEAR VERONA, ITALY.
(Siphon Spillways in Foreground of View.)

The advantages which may be gained by using these siphons on canals, dams, etc., are considerable. In the first place, their use permits economy in ground space, and in construction. In order to comprehend this, one needs only to compare the ground plan of the Turbigo hydro-

electric plant (near Milan), equipped with ordinary overflow spillway, with that of the siphon spillway installation near Verona (Fig. 4). Both plants discharge about the same volume of water (2,500 and 2,800 cu. ft. per sec., respectively). That at Verona is worked from a face 59 ft. in length, with 3 in. as the greatest variation in the water level, while that at Turbigo is 300 ft. long and a rise of nearly 2 ft. had to take place before the quantity of water required could flow over. As a matter of fact, the action of the spillway at Turbigo has been supplemented by the use of three outlet gates automatically raised by electric motors.

It is thus self evident that when the variations in the water level must be restricted within moderate limits, the use of the ordinary open spillways involves the construction of extensive works and a corresponding heavy cost. The advantages of the siphons naturally show up much more clearly in cases where the space is somewhat limited, as, for example, when the spillways are constructed in tunnels.

Not infrequently on technical or legal grounds, great variations of the water level are not permissible. For example, in the great canal systems of Italy the maximum variation permissible is fixed by the State at 8 ins. Again, in the working of turbines of hydroelectric plants, the demand for uniform voltage and current has defined the limiting conditions between which variations of the water level must be restricted. In the use of movable dams due regard must be paid to the owners of other plants in the matter of keeping the high level constant, so that in order to make full use of the effects of the spillway, one is practically compelled, in ordinary working, to keep the high level lower than that theoretically permitted by an amount equal to the depth of the vein of the spillway. Similar conditions hold for reservoir dams, for there not only the head available, but also the volume of the reservoir, are very liable to variations when open spillways with great size of vein are used. In all such cases, the spillway siphon, by reason of the smallness of the variations that it permits, has proved itself a most economical expedient. Reference must also be made again to the readiness with which it comes into action, and which makes it much favored in those places where it is necessary to reduce to a minimum the small unavoidable irregularities of water discharge, in consideration for the owners of other plants.

The Engineering School Graduate; His Strength and His Weakness.*

By HENRY P. TALBOT.†

One needs only to review the conditions of the last quarter century to realize that an extraordinary change has taken place in the position of the engineer in the community. None of the older professions have been called upon to face such kaleidoscopic conditions and it is not strange that there should be a dearth of men immediately adapted to meet the altered situation, or that many should be found to be partially lacking in the extremely composite training which would lead to complete command of the field. It may not be irrelevant to ask whether the so-called learned professions, so long regarded as superior to the engineering professions, would have fared distinctly better under a like extreme test.

The wholly successful engineer of the day (I do not speak now of the recent graduate) must be a man possessing a capacity for logical, quick and exact thought; a detailed knowledge of some portion and a broad knowledge of the whole of his professional field; and be master of a certain amount of the technique of his profession. He must have the ability to select and guide competent and trustworthy associates and to obtain from them loyal and willing service. He must be strong in his sympathies and generous in his public services, and while quick to enlist desired interest in his enterprises he must be shrewd in detecting avarice or perfidy. He should be a loyal husband and father, and should find opportunity for that enjoyment of art and literature which will afford him present pleasure and ensure the happiness of advanced years.

It is a matter for sincere rejoicing that the engineering profession has reached such a commanding position in our national life that only a man of this type can completely fill it; but the imperfect portrait just drawn is evidently that of a man for whom Nature must have done much at the start, and toward whose efficiency many elements must have contributed.

Of the need of such men there is no doubt, and it becomes a question of paramount importance to ask how far the engineering schools, as such, or indeed how far our entire educational machinery can contribute to the desired end. The most obvious function of the engineering school is to afford a fundamental knowledge and understanding of the principles of the sciences underlying engineering operations. Failure to do this seems to be without excuse, yet it is almost inseparable from another important function, namely the development of the power to think (for there can be no adequate understanding of principles unless one can think logically in terms of them when considering concrete problems), and it is just at this point that much of the current criticism is aimed.

The candid teacher must admit that there is truth in the charge that the graduates are too often lacking both in a capacity for logical thought and in an ability to command the knowledge which they actually possess to the degree needful for immediate or perhaps ultimate success in their vocation. But it should not be supposed that he is indifferent to this state of affairs.

It is within bounds to say that it is the supreme desire of every worthy teacher to encourage power of thought rather than mere acquisition of knowledge on the part of his pupils and that he is constantly devising and testing new means to that end, but a moment's consideration will show you how much this depends upon personal contact,—now so difficult in even the smallest practicable subdivisions of large classes—and will convince you that there must also be constant conflict of judgment as between the extent of the field to be covered in a given subject (rarely more than the minimum quantity nowadays) and the time which can properly be spent in that drill which is necessary to develop the powers of the average student; for it is against the average student that the criticism is most valid.

Let it be remembered, moreover, that some responsibility for these conditions rests upon our public school system, and also that the sort of thinking which the engineering professions demand is of a kind which is more exacting than is essential in the more common vocations, and that no system of education has yet succeeded in training a large proportion of exact thinkers, however much such a result is to be striven for.

Let us also admit for our encouragement that, after all, there is a considerable proportion of our engineering graduates who can use their brains effectively and do have their knowledge in available form, and my observation leads me to believe that there is a much larger proportion who appear deficient in these respects at graduation who develop unexpected power when they have opportunity to concentrate their efforts in a more limited field.

Remember that many of these youths have been in some sort of educational training for a continuous period of fifteen to seventeen years, during which there has been a constant (but sometimes unwise) increase in the pressure put upon them to cover more ground. Is it strange that they have lacked an opportunity to sort their immense stock, or to become familiar with it? They are, I think, entitled to charitable consideration for a time after entering their vocation, but if as a class they are deficient after three years, the criticism of them or of their training certainly becomes valid.

But in our epitome of the distinctly successful engineer of maturer years was included breadth of knowledge within and without his profession, the quality of leadership, which means power of imitation and a knowledge of men, and the ability and inclination to fulfill the requirements of good citizenship. Are the graduates from the engineering schools, as a class, in line to develop thus symmetrically? Let us admit again that many are not and that that is the occasion of the general charge of "narrowness" and inadequacy which is directed against our courses.

But here again I venture to assert—not, however, in a spirit of complacency—that the situation is more complex than is generally admitted, and that there is a good deal that is encouraging in the situation.

Recall once more how short a time it is since the engineer has occupied a position in the community which is recognized to be of equal dignity with that of the so-called learned professions, and recall how recent is that evolution of our industrial system, which has as its most important feature the recognition of the fact that the engineer and the financier, if not combined in the same individual, must be on a parity with respect to influence and authority if efficiency—the watchword of the hour—is to result. Is there not cause for congratulation that some have been found in the engineering ranks capable of meeting this surprising increase of responsibility rather than ground on which to pronounce the general result of engineering education a failure, as some seem inclined to do?

One serious difficulty which technical schools are encountering has been frequently referred to by recent writers but deserves a mention here, namely, that of securing and holding broad, cultured teachers.

Specialization has invaded the teaching profession, especially in scientific lines, where the mastery of any large field of knowledge to a degree corresponding to the needs of the expert is rarely possible. The specialist is apt to use the microscope far oftener than the field glass and this habit is partially reproduced in his students.

It is encouraging to note that certain schools are now recognizing the need of men who are efficient teachers with a broader outlook, to deal especially with the younger men. They are recognizing that not every eminent specialist or successful investigator is a successful teacher, more particularly in this very matter of breadth of view, and are leaving the specialists greater opportunity for the presentation of their specialties to the older classes, while improving the instruction in the more general courses.

It is obvious that these difficulties are enhanced by the larger financial rewards which tempt the broad-minded engineer away from the schools. A single instructor who exemplifies the cultured scholar and gentleman in ease of manner and grace of diction does more for the cause of scholarship and culture than any quantity of sound advice can do; for, I fear that it is utopian to hope that a majority of the students with whom the study of engineering is their main purpose will ever believe that any man is disinterestedly sincere in his advice regarding such subjects as literature, language, art or economics, unless he makes it quite clear to them that these subjects have a distinct significance to him and are a part of his life. Just here lies one of the great obstacles to the elimination of "narrowness."

If the inculcation of breadth of view and love of the refined in life is difficult, the development of qualities of leadership is even more so. That these qualities are largely conferred at birth will, I suppose be generally admitted, but I take it that the criticism of lack of leadership is really directed toward an alleged culpable lack of facility in getting the best from others, of appreciating the point of view of others, or of presenting our own views to others.

If this indicates a failure on our part to stir the ambitions of our students to avail themselves of opportunities which come to them, or to plan for themselves a really worthy career, then we are at fault; but if it means that the faculties of engineering schools should further encourage those forms of activity commonly designated as "college life," then I believe that we are on debatable ground.

Of the importance of these traits which enable a man to win the confidence and respect of his fellow men, to "succeed" among men, no one could be more conscious than I. In individual cases they may indeed be more potent factors than accuracy of scientific knowledge in securing preferment, and any man is fortunate who combines engineering skill with ease of manner and persuasive speech.

Let the schools realize by all means, their responsibilities for the development of men as well as engineers, and encourage by precept and especially by example an interest in all that tends toward a better understanding on the part of our students of their human relations, including prudent encouragement of the so-called "student activities."

But let those who lack a realization of the great changes which the student life at our technical schools has already undergone in the last few years, and who therefore constantly clamor for more of what is called "college life," reflect that one of the greatest assets which a graduate from one of these schools can take with him when he leaves it is the well established habit of "doing a days' work in a day," of meeting his obligations on time, and let him realize that this cannot be reasonably demanded if the instructors must in fairness accept excuses because of an undue diversion of time and energy to other things.

If I have dwelt more upon the alleged weaknesses of the engineering school graduates than upon their strength, it is because the latter is attested by the engineering advance of the recent past to which they have contributed to an extent which would not have been possible had not the majority of them received from the schools an education and training which has proved useful, dependable and stimulating.

I believe that the large majority of the engineering school graduates are virile, intelligent, and industrious, with sound habits of thought and great capacity for work, ambitious to make the best of themselves, possessing a sincere desire to acquit themselves honorably both in private and public life and with an increasing ability to do so. As such, we, their instructors, honor them and ask your cooperation, advice and encouragement in our efforts to give to them what they deserve at our hands. We ask you also to recognize that while for the moment the rapidly changing social and industrial condition may have outrun our ability to adapt our educational practice to them, we are not lacking in an appreciation of the significance of these changes or of our obligations for the future.

*From a paper presented before the Congress of Technology at the Fiftieth Anniversary of the Granting of the Charter of the Massachusetts Institute of Technology.

†Professor of Inorganic and Analytical Chemistry, Mass. Inst. Tech., Boston.

A Special Design of Retaining Wall for the C., M. & St. P. Ry.

By J. H. PRIOR.*

The engineering department of the Chicago, Milwaukee & St. Paul Ry. has just completed the construction of a long retaining wall at Elgin, Ill. This retaining wall, which was designed and constructed under the direction of Mr. C. F. Loweth, Chief Engineer, is of somewhat unusual design. The circumstances which led to the selection of this particular type are described in this article.

A railway retaining wall can be described usually as a structure such as is shown in Fig. 1, which prevents the embankment from extending

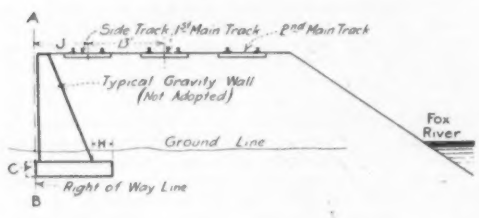


Fig. 1. Location of Retaining Wall at Elgin, Ill.; C., M. & St. P. Ry.

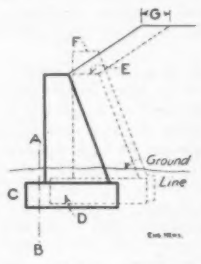


Fig. 2. Retaining Wall for Surcharged Load

to the point at which the natural slope of its material would intersect the ground line. Where it is necessary to build a retaining wall to keep the embankment from encroaching on the ground to the left of the line (A-B), it will also be often necessary to keep the footings from encroaching on the land to the left of the same line (as shown by the dotted line C), especially in centers of population or industry, where land values are high.

Where the embankment which the retaining wall restrains is surcharged, as shown in Fig. 2, the location of the toe of the footing can be moved from the position (C) to the position (D). The toe of the footing, having been thus moved so as to be entirely on the land of its owner, the designer has the choice of building the wall to the height (E), and losing the use of the land of the width (G), or of building the wall to the height (F) and obtaining the use of the land (G). In making a decision, the value of the land represented by the strip (G) will be compared with the additional cost of the higher retaining wall (F) over the retaining wall (E).

Assume that the top of the embankment is flat, as shown in Fig. 1, and that it is required that the footings should not project beyond the right-of-way line (A-B). The full use of the right-of-way can only be obtained by removing the front projection of the footing (C) and by extending the footing beyond the rear of the wall (as at H) whatever distance is required to give a stable retaining wall of plain concrete; or else by using some special design in reinforced-concrete.

The situation represented by Fig. 1 recurs often enough in railway work to give the matter considerable general importance, especially where the allowable bearing of the toe of the footing upon the foundation is low. The same circumstances which make it necessary to build a retaining wall to keep the railway embankment within the right-of-way tend to make it necessary also to keep the footings of the retaining wall within the right-of-way. Such a situation occurs at Elgin, Ill., where the right-of-way of the railway company occupies a narrow strip on the west bank of the Fox River. The ground to the left of the right-of-way line (A-B) is occupied by a row of mills and factories which abut on the right-of-way line, and so the footing could not project to the left of that line. The wall could not be moved to the right, in order to keep the footings from projecting beyond the right-of-way line, as it was necessary to maintain the present distance of the side track from the right-of-way line; this distance is determined by the use made of the side track. Test pits showed the allowable bearing on foundation to be about two tons. Piles could not be driven, as their driving would interrupt the use of the side track and would disturb the foundations of the adjoining buildings.

To meet the above conditions five types of wall were designed, shown in Figs. 3 to 7. The comparative quantities and costs are shown in Table I. The cost in each case covers only the items tabulated, and does not include such special items as excavation, falsework, etc. These latter are subject to such wide variations that it was thought best to omit them in this comparison, as their insertion would introduce a large amount of guess work. The items shown are those which must be taken account of in every situation, and the reader is left to add whatever special items are required to cover conditions in other places. The unit prices which were selected were given values which would make them as general as possible. The quantities being given, other unit prices can be substituted by the reader, if he desires.

Each of the above walls was investigated for three conditions of loading: Case I., live load on side track only. Case II., live load on first main track only. Case III., live load on both tracks. The comparative results are shown in Table II.

Type A. Plain Concrete Retaining Wall.—This type is shown in Fig. 3 and its design requires no explanation. This figure shows that the differences which are developed between the loadings of Case I. and Case III. are so small for this design that they could have been neglected. The different cases of loading are retained, however, both to show the slight difference which exists between them and to show the same information throughout all designs, instead of omitting information which proved unimportant as the design was worked up. This design has a maximum bearing on the toe of footing of 5,700 lbs. per sq. ft., and its cost per lin. ft. of wall is $31.94. This bearing was greater than the foundations would carry; causing the rejection of this design.

Type B. Cantilever Retaining Wall of Reinforced Concrete.—All the essentials of this design are shown in Fig. 4. This wall has a bearing at toe of footing of 5,470 lbs., and a cost of $29 per lineal ft. It was found unsuited for the situation for the same reason as Type A; excessive bearing on toe of footing.

Type C. Buttressed Retaining Wall of Reinforced Concrete.—This is shown in Fig. 5 and is the ordinary buttress retaining wall. Bearing on toe of footing, 5,970 lbs. per sq. ft.; cost per lin. ft., $29.26. Rejected for the same reason as types A and B; excessive pressure on toe of footing.

Type D. Cellular Retaining Wall filled with Earth.—This wall (Fig. 6) is formed of two longitudinal curtain walls (A) and (B), connected by two transverse diaphragms (C). The vertical space between the parallel longitudinal walls and the transverse diaphragms is filled with earth. The maximum pressure on toe of footing for this type is 4,250 lbs.; the cost per lin. ft. is $42.15. This design also was rejected on account of the high pressure on toe of footing.

Type E. Adopted Design.—This construction, shown in Fig. 7, is the design of W. S. Lacher. It is a new type in reinforced concrete, as far as the knowledge of the writer goes, but is an old type in stone masonry, having been illustrated in Benjamin Baker's "Actual Lateral Pressure of Earthwork," 30 years ago.* The wall con-

*Assistant Engineer, Engineering Dept., C. M. & St. P. Ry., Chicago.

*See pages 67 and 69; "The Actual Lateral Pressure of Earthwork," Benj. Baker; D. Van Nostrand, New York, 1881.

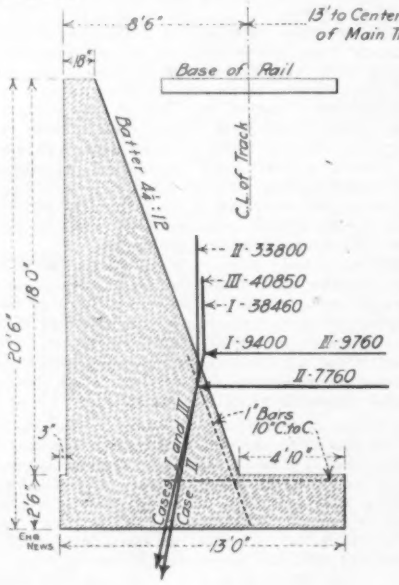


Fig. 3. Design A. Plain Gravity Retaining Wall.

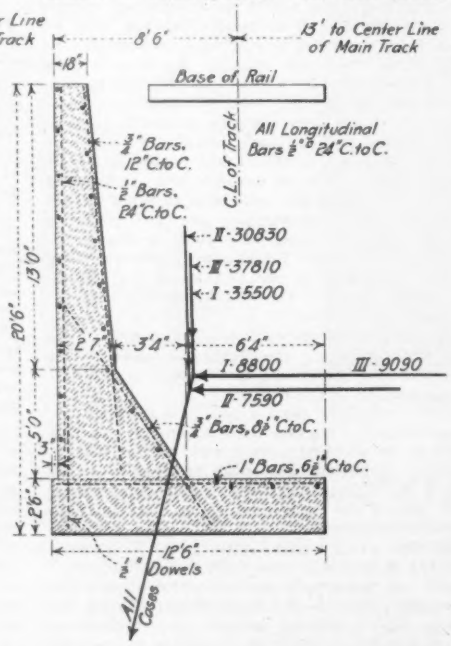


Fig. 4. Design B. Cantilever Type of Reinforced-Concrete Retaining Wall.

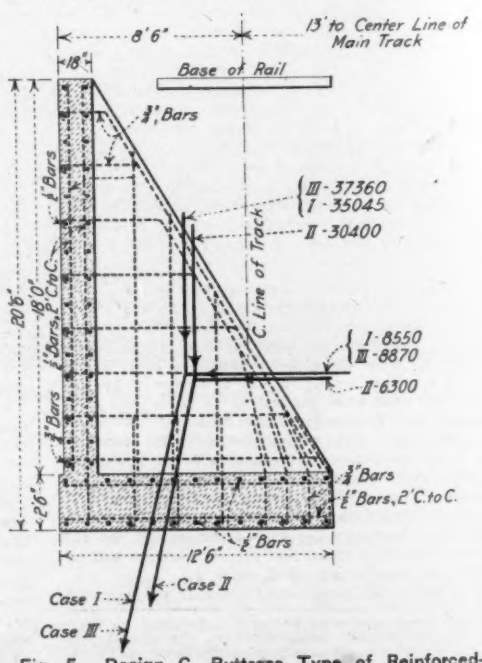


Fig. 5. Design C. Buttress Type of Reinforced-Concrete Retaining Wall.

TABLE I.—COMPARATIVE COSTS OF RETAINING WALLS OF DIFFERENT DESIGNS. (Cost per lin. ft.)

Materials and unit prices.	Type A. Quantity.	Type A. Cost.	Type B. Quantity.	Type B. Cost.	Type C. Quantity.	Type C. Cost.	Type D. Quantity.	Type D. Cost.	Type E (adopted). Quantity.	Type E (adopted). Cost.
Concrete: $6 per cu. yd.	4.33	$25.98	.....	.....	1.15	$6.90	1.15	$6.90	1.20	$7.20
Footings, $6 per cu. yd.	....	.....	1.15	$6.90	.....	.....	.....	.....	1.09	$6.54
Neat work, $7.50 per cu. yd	....	.....	1.80	13.50	1.44	10.80	2.12	15.90	1.67	12.50
Slabs, $9 per cu. yd.	....	.....	.....	.....	.....	.....	.....	.....	0.62	5.58
Steel, 2½ cts. per lb.	40.8	1.02	148	3.70	151	3.78	270	6.75	250	6.25
Forms, $1.20 per sq. yd.	4.12	4.94	4.12	4.95	6.4	7.78	10.25	12.30	9.9*	11.88
Total cost per lin. ft.	....	31.94	.....	29.05	.....	29.26	.....	42.15	.....	42.75
Cost of steel per cu. yd.	....	0.24	.....	1.26	.....	1.46	.....	2.03	.....	1.85
Cost of labor and material, per cu. yd.	....	7.14	.....	8.59	.....	9.85	.....	10.65	.....	10.80

*Including forms for slabs.

TABLE II.—COMPARATIVE BEARING PRESSURES OF RETAINING WALLS OF DIFFERENT TYPES.

Bearing Pressures; lbs. per sq. ft.

Type.	Case I. First track loaded. Toe.	Case I. First track loaded. Heel.	Case II. Second track loaded. Toe.	Case II. Second track loaded. Heel.	Case III. Both tracks loaded. Toe.	Case III. Both tracks loaded. Heel.	Cost per lin. ft.
A	5,320	590	4,570	630	5,700	370	$31.94
B	5,360	560	4,400	550	5,470	605	29.00
C	3,610	0	4,030	830	5,970	0	29.26
D	4,250	1,880	3,800	1,200	4,220	2,170	42.15
E	2,280	2,280	2,580	510	2,160	2,630	42.75

sists of a footing (Y) which supports a longitudinal wall (T) and the cross walls (U). The cross walls which are spaced about 12 ft. centers, connect at one end to the longitudinal wall and at the other end support the girder (X), which spans from one cross wall to another. Above the girder, the slabs (V) are supported at one end by the girder and at the other end by the longitudinal wall. The drawings show the design in sufficient detail.

It will be noticed that in this design the maximum pressure on the toe of the footing is only 2,580 lbs., which is only 61% of the next lowest bearing (type D) or 43% of the highest bearing (type C). The cost per lin. ft. of this wall is $42.75. As this cost is greater than any other types, this design is only suitable to the situations described in the opening paragraphs; namely, where the retaining wall must give full use of the right-of-way and low bearing on the toe of the footing. As this was the situation at Elgin, the wall of type (E) was adopted and built.

In this adopted design, the greatest reduction in toe pressure is brought about by eliminating the weight of the earth directly above the footings, the space between the cross walls (U) being an open and empty space in this design. As the vertical loads on the footing are thus diminished and as the horizontal loads are not much altered, the inclination of the resultant of the vertical and horizontal loads is increased. In the resultant marked Case II. (Fig. 7) the ratio of the horizontal to the vertical components is 0.41; as this ratio might exceed the coefficient of friction of the wall on a slippery foundation, this wall is somewhat unstable if built on such a foundation and its tendency to slide is the principal weakness in the design. This weakness, of course, is partly remedied by the depth and compactness of the backfilling in front of the wall.

In making these comparisons, it was not thought practical to find the cost of the wall of different types having exactly the same toe pressure, but instead each type was proportioned in the manner which it was thought would show it in the most favorable way as a whole.

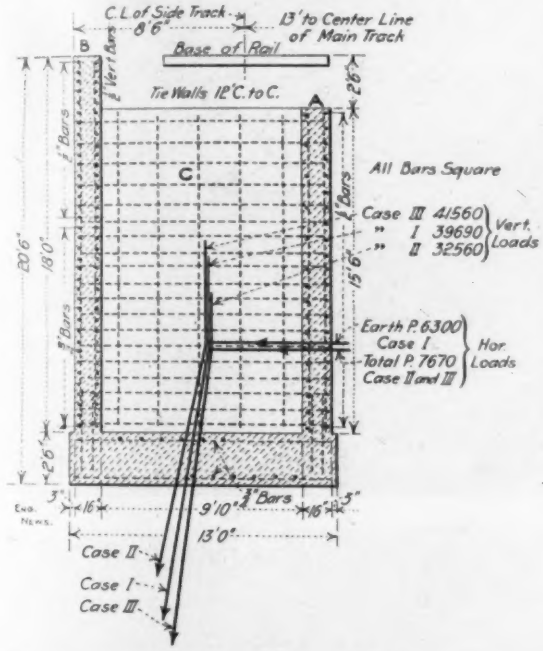


Fig. 6. Design D. Cellular Type of Reinforced-Concrete Retaining Wall.
(With earth loading in the cells.)

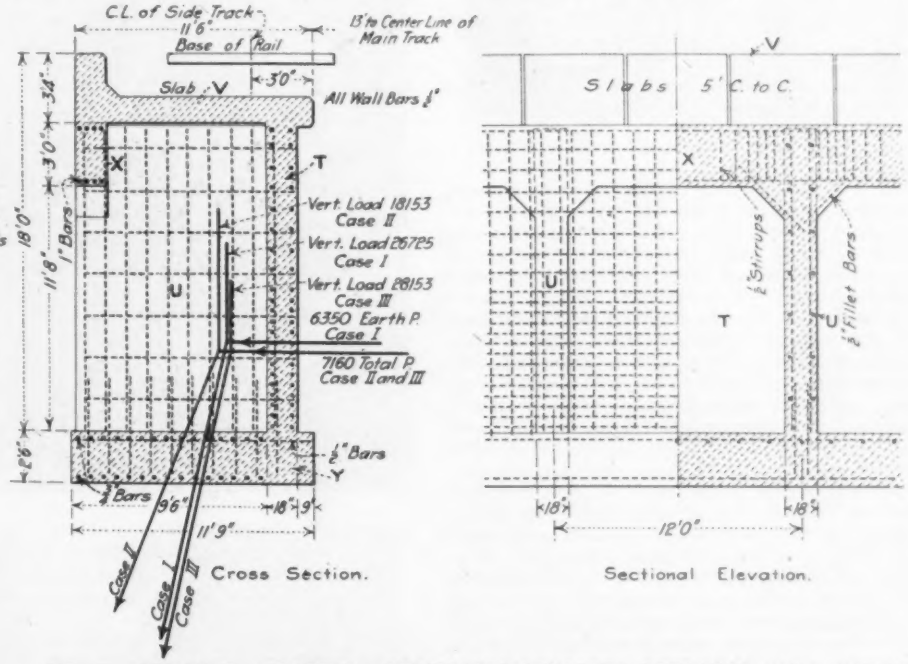


FIG. 7. DESIGN E. (ADOPTED). REINFORCED-CONCRETE RETAINING WALL WITH OUTSIDE BUTTRESSES AND SLAB DECK.

Recommendations for Use in Chicago Street Paving Specifications.

Changes in paving specifications of Chicago are recommended in a "Preliminary Report on Street Paving," made by Mr. Samuel Whinery, M. Am. Soc. C. E., New York City, to the Chicago Commission on City Expenditures some months ago, and which is made available through publication in pamphlet form. We print below a summary of Mr. Whinery's recommendations, this summary having been prepared by the Commission just named:

General Specifications.—(1) That paving specifications and requirements be adapted to meet the varying conditions in different parts of the city, instead of being uniform, as at present. In this way a large sum may be saved annually.

(2) That the use of natural cement as at present should not be permitted.

(3) That *standard plans* be attached to all contracts, instead of relying upon verbal descriptions.

(4) That curbstones should be set on a bed of hydraulic concrete, rather than on blocks of stone.

(5) That the contract clauses requiring "change of plans" and "extra work" be made more full and definite than at present.

(6) That specifications for concrete foundations require that the cement be measured in the original package, rather than in loose condition, as the volume of loose cement will be greater than its volume in the package.

(7) That the use of wooden headers be discontinued and stone headers substituted.

Brick Pavement.—The recommendations under this head are as follows:

(1) That the specification as to dimensions of brick be changed so that it may not exclude competition of a number of manufacturers, as is done under the present specification.

(2) That in the clause permitting the admission of brick that lose 20% of their weight in the rattler, the figure 20 should be changed to 18.

(3) That brick be laid in gutters in courses parallel to the curb, rather than at right angles.

(4) That grout filler be used for brick paving instead of bituminous filler, except in cases where the closing of the street for the necessary time would be a serious hardship.

Asphalt Pavement.—The following recommendations are made in respect to asphalt pavements:

(1) That the use of experimental asphalt be discontinued, and that the specifications cover in greater detail the qualities of the crude asphalt and the method of refining it.

(2) That careful consideration be given to the suggestion that the city itself supply the contractor with asphalt for paving purposes, leaving only the construction of the pavement to the contractor.

(3) That adequate specifications be provided, and strict compliance under expert supervision be insisted upon.

Creosoted Block Pavement.—Under this heading the following recommendations are made:

(1) That the botanical name of the timber desired be stated in order that there may be no misunderstanding.

(2) That if it is desired to exclude all but true long-leaved yellow pine, the specifications be changed accordingly.

(3) That the specifications for creosoted oil be so changed as to break up the monopoly now enjoyed by one concern, and in order to prevent the exudation of tar on the pavement in the hot weather, as at present.

(4) That the transverse expansion joints be at least ½ in. in width, in order to prevent heaving and breaking.

(5) That sand be used for filling between the joints instead of pitch, as the pitch, when combined with the oil, renders the pavement objectionable.

Granite Block.—Under this heading the following recommendation is made:

(1) That specifications for dressing granite block be changed to a practical basis, as indicated hereinafter, and that joints be filled with grout.

Concrete Sidewalks.—Under this heading the following recommendation are made:

(1) That adequate drainage be provided for foundation of cement sidewalks, and that the thickness of the foundation course be reduced to 6 ins., instead of 9 ins., as at present.

(2) That leaner and cheaper concrete be used for the base course of concrete.

(3) That, instead of laying alternate blocks of pavement, the cost be diminished by providing expansion joints.

(4) That the course of concrete at roadways be made, respectively, 5 and 1½ ins. thick, instead of 7 and 2 ins., as at present.

Street Repairs.—Under this heading the following recommendation is made:

(1) That the cost of street repairs, especially of asphalt and granite block, be carefully studied, with a view to reducing excessive costs.

Vehicle Tax.—Under this head the following recommendations are made:

(1) That a different system of tags be substituted, as indicated hereinafter.

(2) That the date of taking out the license be changed from April 30, as at present, to March 1, in order that the Bureau may plan more intelligently the repairs for the season.

(3) That the system of expending the vehicle tax in the particular wards where collected be abandoned.

Profitable Refinements in Contractors' Compressed-Air Plants.

By FRANK RICHARDS,* M. Am. Soc. M. E.

To those most familiar with compressed-air practice in the United States, it would seem that the possible economies and the best efficiencies have been worked out and adopted quite slowly if not almost with reluctance. And yet the period covered from the beginning of the modern, and now general, employment of compressed air for power and other purposes is not much more than a quarter of a century. It was adopted at first upon compulsion and not by choice. For the driving of rock drills in tunnels and mines there was no other means in sight and its employment became imperative, also for resisting the inflow of water where men were employed below water level, for example in the sinking of caissons for bridge piers and other foundations.

These and the numerous other industrial uses of compressed air which have so rapidly developed have made a sure and permanent business for compressor builders; yet, while compressed air was thus adopted with the evident assurance that its employment was to continue

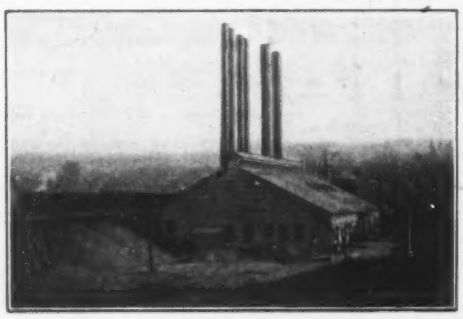


Fig. 1.

and to constantly grow, there was rarely any apparent attempt to get the most out of it for the least possible cost. The compressing plant, almost always steam driven, was generally of a provisional or temporary character and wasteful in nearly every particular. The typical air compressor of that day, the standard compressor of the most prominent builders, was a plain slide-valve steam engine with a single-stage air-compressing cylinder; steam was furnished by any old boiler which could be made available; engineers and firemen had a hard time of it, and compressed air was charged and discredited with the wastefulness of the entire system.

Without going into figures at all, it is quite safe to say that in typical and entirely up-to-date plants of the present day the air is delivered much more satisfactorily and reliably and at not more than one-third of the net cost for fuel and labor as compared with the majority of plants of only 20 years ago. This astonishing advance and improvement has not come in consequence of any new discoveries which have been made relating to principles involved in compressing, transmitting or using compressed air, nor of any revolutionary mechanical inventions in this field. Practically all that is known about air, its properties and its action under given conditions was known 20 years ago to scientists and investigators, and it has now become known and been practically applied by engineers.

The Principal Economies at the Steam End.

In the steam-driven air-compressing plant, the improvements have been greater in the steam drive than in the air compression. Although, owing to the character of the work, a large air-compressing plant is frequently to be regarded as a temporary one (as, for instance, for the tunnel and subway and railway station excavations of New York City, or on the large contracts of the Catskill Aqueduct) still it is found to pay to install all the devices and arrangements of an economizing character which would belong to the most permanent lines of employment.

*Managing Editor, "Compressed Air Magazine," 11 Broadway, New York.

In the magnificent installation of the T. A. Gillespie Co. for the Rondout Siphon, at High Falls, N. Y., part of the new Catskill Aqueduct system, all the familiar steam economizing devices were employed, such as high-pressure steam (150-lb.) and compound steam cylinders, with condensers, feed-water heaters and economizers. This installation, by the way, is believed to be the largest high-pressure air-compressing plant in the world.

It is customary to think only of the fuel saving in such a case as this, but the labor saving also cuts a figure which quite compels notice. Here were ten large duplex Corliss, compound steam, two-stage air compressors running day and night up to full capacity, developing over 4,000 HP. and delivering 24,000 cu. ft. of free air per minute compressed to 110 lbs. gage, using 100 to 110 tons of "birdseye" coal per day, with hand firing; and yet the entire operating force, including engineer-in-charge, was only eight men to each 8-hr. shift.

Fig. 1 gives a general view of the exterior of this plant and Fig. 2 shows as much of the interior of the compressor room as it seems to be possible to get into a single view. As descriptions of this interesting plant have been published,* it is not necessary here to go more into details, except upon the special topic before us, and thus we come at once to one of the things worth while which are there employed, but which are not as generally adopted as they should be.

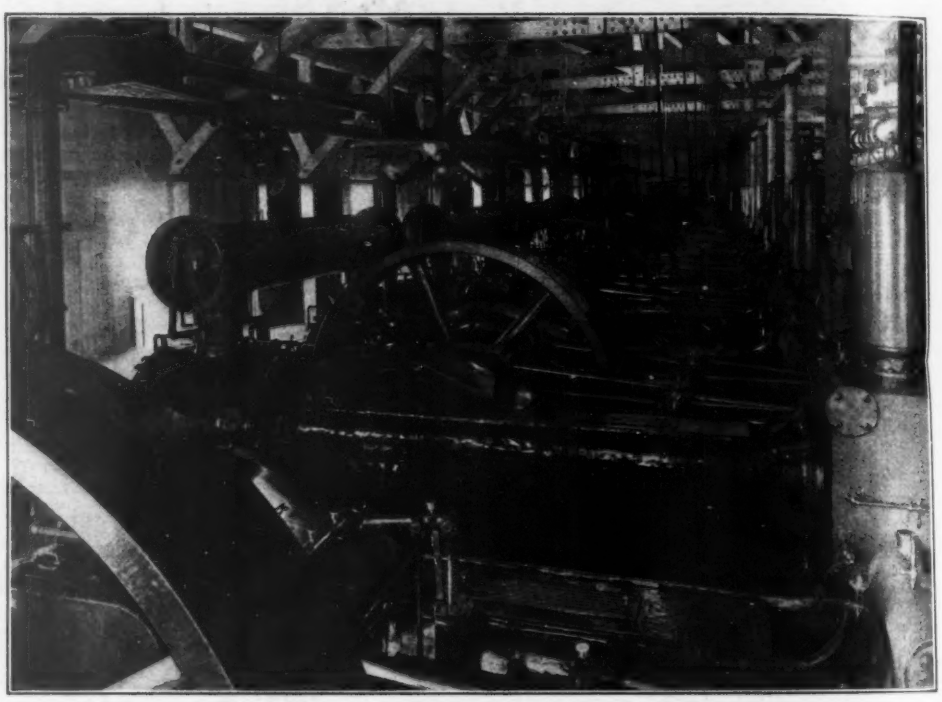


Fig. 2.

FIGS. 1 AND 2. EXTERIOR AND INTERIOR VIEWS OF A CONTRACTOR'S AIR-COMPRESSING PLANT.

(The Power House of the T. A. Gillespie Co. at High Falls, N. Y., Rondout Siphon Contract, Catskill Aqueduct.)

Aftercoolers.

An aftercooler is a desirable addition to an air compressor. It at once brings the air down to nearly normal temperature, thus reducing its volume. This saves pipe friction and sometimes even permits the use of a line pipe of somewhat smaller diameter. In the High Falls plant, there is a large and efficient aftercooler connected to each pair of compressors, through which all the air passes before entering the distributing pipe. One of these aftercoolers with its companion air receiver is seen in Fig. 3. The air from the compressors enters the aftercooler at the top and passes out of it at the bottom into the air receiver, and then out of the air receiver near the top at the side toward the wall through a pipe which cannot be seen in this view.

The cooling surface provided in the aftercooler consists of a large number of vertical brass tubes of small diameter, and as the water is inside the tubes, with only sufficient head to cause the proper circulation, while the air pressure is outside the tubes, they can be made, and are made, very thin. These tubes are accurately spaced to give the same air space around each, and as the symmetrical grouping of circular figures naturally assumes the hexagon, the steel shell of the aftercooler is made of this shape (as shown in Fig. 3) to correspond, leaving about the same air space around the tubes as between them. The total air space corresponds to the capacity of the air pipe, so that in the movement of the air through the aftercooler all the cooling surface of the tubes is effective without the use of baffle plates or other devices. The water circulates upward through the tubes while the air flows downward around them, the final cooling of the air thus being done by the coolest water.

Besides the cooling of the air and the reduction of volume effected by the aftercooler, a more important service expected of it is the elimination of the surplus water in the air after compression. All free air as taken into the compressor contains much moisture, the normal amount being, say, one-half as much as would completely saturate it. Then when the air is compressed, as in this case, to one-eighth of its normal volume, there is certain to be a lot more water than the air will sustain. This surplus water, if not got rid of, becomes a source of serious trouble both in the transmission of the air and in the ultimate use of it in drills or elsewhere.

When the air is at its highest pressure and at its lowest temperature, as it should be just after passing the aftercooler, both the high-pressure, or reduced volume, and the low temperature are conditions which reduce the moisture-bearing capacity of the air, and then is the time when the air will surrender the greatest amount of water. Water and oil are accordingly deposited in the air receiver and can be drawn off as frequently as the accumulation may demand.

Separating Water From the Air.

This is quite simple in the telling of it, but in practice only partial and unsatisfactory results are secured by this arrangement. Water in air when not in sufficient quantity to saturate it, is evenly distributed all through the air as invisible vapor. After the saturation point is reached, the surplus of water will still be distributed all through the mass of air, but this time as

*"Engineering Record," April 10, 1909.

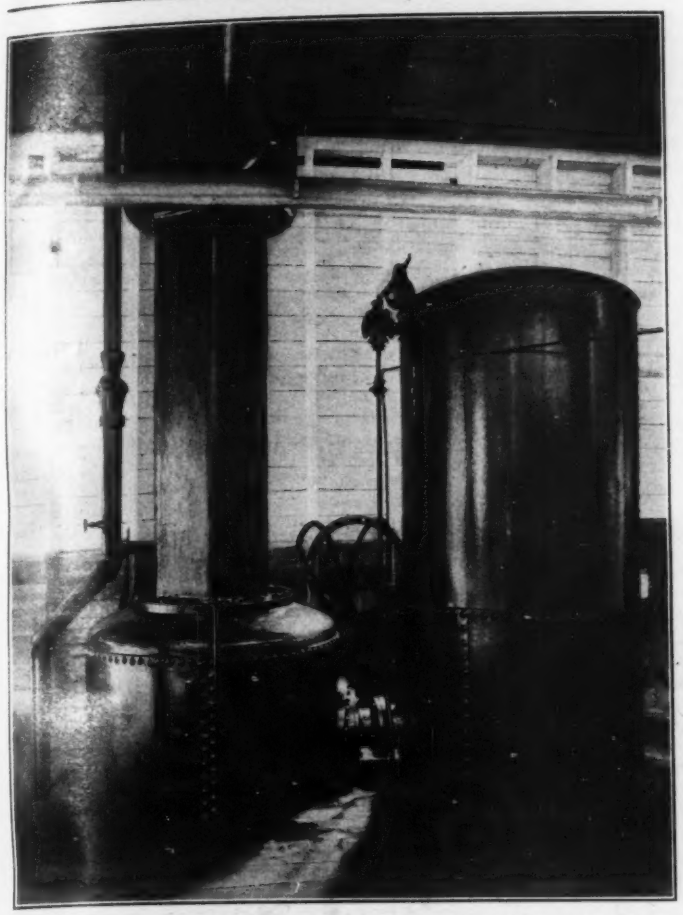


FIG. 3. AFTERCOOLER AND AIR RECEIVER AT THE HIGH FALLS PLANT.

lates in considerable quantities, and is drawn or blown off by the little vertical pipe shown in the sketch. The baffle plates at the bottom of the separator have holes or passages through them so that all the accumulated water can reach the blow-off pipe. On account of the pressure always existing in the separator, the water may be drawn off from the top, as shown, as easily as from the bottom.

DUNWOODIE PLANT.—The plant of another Catskill Aqueduct contractor, that of George W. Jackson, Inc., contract No. 54, at Dunwoodie, N. Y., is quite different from the one at High Falls. This contract covers about three miles of tunnel, in clean, solid rock, driven from three shafts and a portal, giving seven headings to work at. The compressor plant comprises six two-stage compressors with a total free-air capacity less than one-half of that at High Falls. These compressors are driven by electric motors which take current from a power-house in the city of Yonkers.

There are no aftercoolers here, so that the air as it leaves the compressors and passes through the receivers is not then cool enough to surrender its moisture as it should. As it flows along through the pipes, however, its temperature soon falls and the water, as we might say, forms a rain in the pipe and accumulates in a flowing stream along the bottom. As the pipe is not level but follows the ups and downs of the ground surface, opportunities for drawing off the water are offered at the low points, and at several of these points effective separators or draining chambers have been inserted, designed by Mr. N. R. Kettring, the master mechanic who had charge of the installation.

This separator, shown in Fig. 5, is a simple cast-iron cylinder with flanges to which cast-iron heads are bolted. The heads are bored eccentrically, as shown, and threaded for the pipe. The eccentricity brings the top of the line pipe at the top of the cylinder, so that the water accumulates in the bottom and may be drawn off as required. The line pipe is partly 8-in. and partly 6-in. The same size of cylinder is used for either size of pipe, the heads being bored and threaded for either size as required. The cylinder is 20 ins. in diameter and 5 ft. long.

On a smaller pipe line I have known a satisfactory water pocket to be formed by inserting in the line a tee of about double the pipe diameter and bushed at each end to fit the pipe. In the side opening of the tee, pointing downward, was inserted a short piece of pipe the full size of the tee, closed at the bottom with a cap and a draincock.

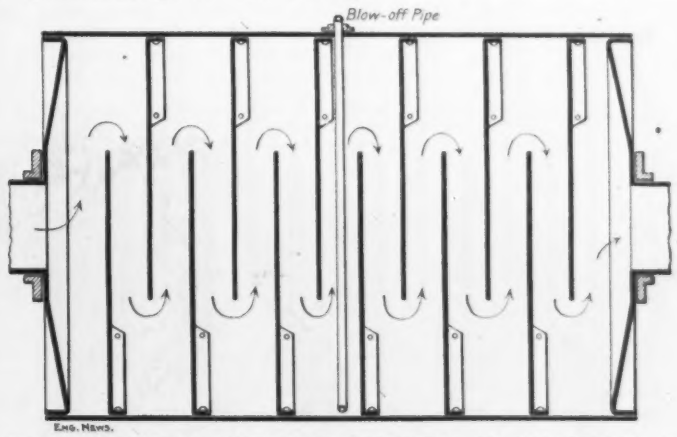


FIG. 4. SECTIONAL SKETCH OF SEPARATOR IN COMPRESSED-AIR PIPE LINE AT HIGH FALLS, N. Y.

actual and to some extent visible globules of water. These are, of course, heavier than the air and in time would descend through the air as a kind of rain and accumulate along the line of pipe or in any containing vessel when the movement was sufficiently slow and protracted. In the rush of the air through the ordinary receiver or pipe line, however, all the water has not the time to settle, and much of it may be carried along to where it will constitute an annoyance or a source of much inconvenience.

HIGH FALLS PLANT.—This was just the experience at the High Falls plant. The water could not be satisfactorily removed at the receivers and there was trouble at the drills. Then the separator, the design and operation of which are sufficiently indicated in Fig. 4, was connected into the pipe line near the power-house. The pipe being horizontal, this is simply an enlargement of it, and the air passes through it in the regular course of business. As it passes through this separator it zigzags up and down past the baffle plates and deposits the water upon their surfaces. This water accumu-

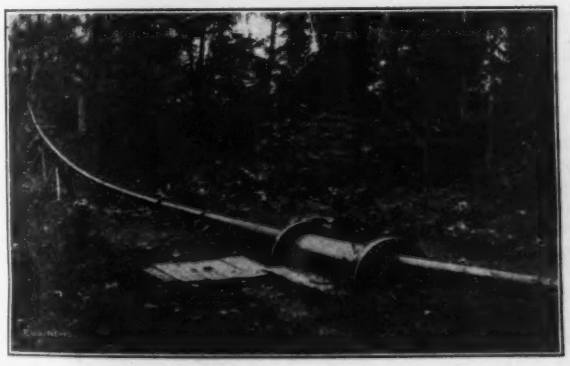


Fig. 5. Kettring Separator in Compressed-Air Pipe Line Near Dunwoodie, N. Y.

Fig. 6. Compressed-Air Pipe Line Carried Over a Highway at Dunwoodie, N. Y.

Tight Piping.

In Fig. 5 we see one of Mr. Kettring's separators picturesquely located at the low point of the 6-in. pipe line between shaft No. 1 and the portal at the northeast end of this section of the tunnel. Fig. 6 is the portion of the line just beyond the view in Fig. 5, this view being taken from the other side of the pipe. The line is here carried over a highway much frequented by automobiles and other traffic. From this point, the pipe is led by an easy slant to the ground, along which it then descends steeply until the scene of Fig. 7 is reached at the side of and immediately overlooking the portal approach.

In these three views, we get a glimpse of perhaps one-eighth of the main pipe line for this contract, suggesting the difficulties encountered in the piping job as a whole. The piping is all bottle-tight, and it may be said that if tight-piping could be had here it can be had anywhere, and air leakage is not a thing which should be expected or permitted.

Reheaters.

The air receiver seen in Fig. 7 is 54 ins. in diameter and 12 ft. high. Similar receivers are located at each of the shafts to steady the working pressure and also to provide a final opportunity for the accumulation of any water that may still be uncollected.

In Fig. 7 is shown also a reheater by which the air is heated before passing to the air-operated steam shovel where it is used. There are ten of these reheaters installed upon this contract, located as near as possible to the pumps, hoists, etc., where the air is used. They considerably increase the volume of the air just before it does its work and also prevent the possibility of freezing up at the exhaust. Reheaters are of course not used for the air consumed in the tunnel itself for driving the drills, and are generally inapplicable where the air is used only intermittently. Especially for driving pumps, however, the saving by the use of reheaters is quite appreciable, although even for this service reliable figures from actual practice are elusive.

Filtering and Cooling Intake Air.

It need not be said that air as it enters the compressor cylinder should be as cool and as free from dust as possible, and in perhaps the majority of the more recent installations some attempt has been made to secure this condition, but more might and should be done. The arrangement adopted is usually merely to lead in an air conduit from outside the building and to so protect the opening that cats cannot be sucked in, or to pipe from the roof instead of taking the air from the engine room itself.

An interesting and effective device for securing cool and pure air for compressors is in use at a plant of the Associated Oil Co., at Kernville, Cal., in the Bakersfield oil district. This, or its equivalent, was an absolute necessity there, as the region is hot and the air is always loaded with dust. The device is so eminently commonsensible, and in use has proved so satisfactory that it is to be recommended for general adoption.

This air filter and cooler is located outside the compressor house, with the hooded intake air pipe standing up in the middle of it as shown in the sketch, Fig. 8. There is just a rectangular frame, or skeleton, made of light scantlings put

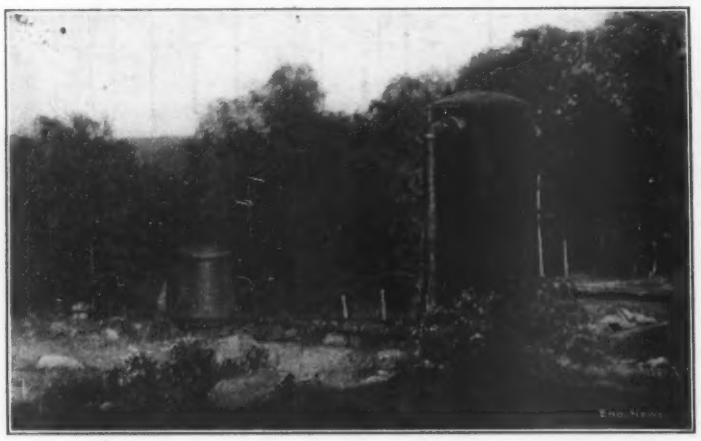


FIG. 7. AIR RECEIVER AND REHEATER AT TUNNEL PORTAL, DUNWOODIE, N. Y.

together by a carpenter. The four sides and the top of the frame are covered with common burlap, tacked on, and the inside is similarly covered, with the thickness of the scantling between the two layers of burlap. This provides on every side two separate filtering surfaces for the air to pass through. Right over the center of the frame is located an ordinary revolving lawn sprinkler, with vertical axis, which slowly turns and keeps all the surfaces constantly saturated and dripping with water. The burlap in this case soon catches so much dust that it can be scraped off in considerable quantities, so that it is frequently necessary to souse the filter, inside and out, with a hose. The frame can be easily lifted off the intake and turned over to expose the inside for the washing.

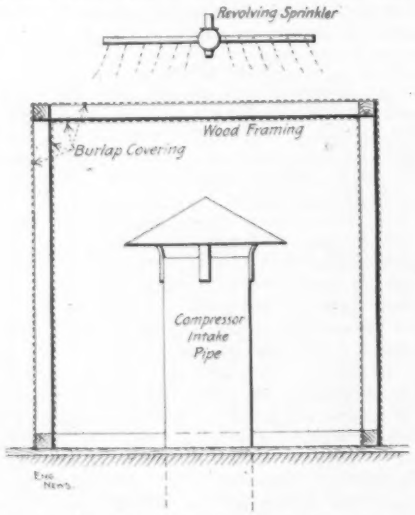


Fig. 8. Air Filter and Cooler for Compressor Intake.

This device not only effectually separates the dust from the air but cools it, through the evaporation of the water, and the air enters the cylinder in unusually good condition. The intimate contact of the water with the air and the probable absorption of more or less water by the air has no effect upon the dryness of the air after compression. For in any case the compression and the subsequent cooling of the air will leave it more than saturated, so that there will surely be free water in the air to be gotten rid of, and a little more or less will make no difference.

Notes on Creosoted Wood Block Pavement.

By PAUL EVANS GREEN,* Assoc. M. Am. Soc. C. E.

There have recently appeared in the various technical papers many highly eulogistic descriptions of modern creosoted wood block pavement, and it is apparent that this pavement is becoming very popular. About the best description of such construction is that by Mr. Wm. W. Marr, M. Am. Soc. C. E., on "Repaving the Loop District of Chicago," published in Engineering News for Dec. 29, 1910. For thorough knowledge of real working conditions this article stands unsurpassed; but it, like many other articles, passes over too lightly some defects of this class of pavement. During the past few years the writer has supervised the construction of about 100,000 yds. of wood pavements and has also been able to see the effect that time and traffic have had on them, and it is hoped that the following observations may have some value.

HISTORY.—If the history of the modern pavement be examined for the past fifty years it is rather amusing to note the wild enthusiasm with which each new departure in paving work has been hailed. In the sixties the "Nicholson Block," which was an untreated rectangular wood block, laid with wide joints filled with coal tar and gravel, became very popular, and many cities, and engineers, too, thought the paving problem was solved. This in spite of the fact that to modern minds there were some very vital faults in the method of constructing these pavements, such as a lack of real foundation. But in spite of that, if American cities had been in the habit of maintaining their pavements as is done abroad, it is probable that the Nicholson would have done very well.

Following the Nicholson in the middle west came the cylindrical cedar block. This pavement, too, immediately leaped into popularity, and for years was laid to the practical exclusion of all others. The wrecks of it we still have with us in hundreds of streets. Again, it may be said that with proper maintenance, even this pavement would have done well, and might still have been in favor on certain classes of streets, for it was of pleasing appearance, noiseless and smooth when first laid and was inexpensive, though lacking sanitary qualifications.

Almost coincidently with the cedar block pavement the modern asphalt pavement was introduced, and this was undoubtedly the greatest advance ever made in paving. To-day it ranks as high or higher than it ever did, is exceedingly popular, and justly so, for it has all the good points that are necessary to make a pavement desirable. It is clean, of pleasing appearance, sanitary, smooth, offers low tractive resistance, is readily repairable and not expensive. But for many years it was terribly abused. The ingredients of the surface course were mixed by guess; the pavement was promoted to death by men who insisted it was the panacea for all pavement ills; its maintenance was neglected, and in many cities a very sharp reaction set in and the asphalt pavement was taboo'd. Its substantial merits saved it, however. Engineers and chemists made a close study of its proper constituents, and its use in streets where improper traffic conditions prevailed was gradually abandoned. City authorities, by a campaign of education, came to understand its limitations, and the great fundamental idea of proper maintenance forced its way to the front, and again this pavement is in high favor.

History is now repeating itself. The creosoted wood block pavement is being hailed as the greatest advance in paving that has ever been discovered, and promoters, with the sole idea of selling their product, have flooded the country with literature tending to show that this pavement is by far the best for any and all locations, no matter what the conditions. Such a propaganda cannot but have its effect, and wood pavement laid under any and all conditions will suffer correspondingly, and in a few years the history of asphalt will be repeated.

It is only proper to say that it is a grand pavement. This has been recognized in Europe for years but its limitations are also recognized there. Like asphalt it is extremely technical in its treatment, and it appears to the writer that it is a very grave mistake to advocate it so indiscriminately. It has a very proper and distinct sphere of usefulness, as have asphalt, brick, granite block and macadam pavements, each distinct in itself and each the best pavement in its place. But also each will fail utterly to give satisfaction outside of its proper field, and the same must be said of creosoted wood blocks. So much has been said in its favor, and it is now being put in so rapidly in many cities, that a few words regarding the nature of the treatment and calling attention to some of the defects which are liable to develop from lack of proper supervision and inspection, inadequate specifications, faulty location, and above all, poor maintenance etc., should not be amiss.

The modern creosoted wood block for pavements consists of sawed rectangular wood blocks, generally about 3½ × 4 ins. and from 5 to 10 ins. long. The block is impregnated with an oil for the purpose of preserving it from decay, and also partly to render it impervious to water. To preserve the wood the oil must contain agents which will destroy the fungi and bacteria causing the rot, and which will not dry up or evaporate at any ordinary temperature to which the timber may be subjected in the street. Any oil, therefore, which is unstable at a low temperature, or which does not contain the germicidal agencies, or whose melting point is so high that the temperature required in the treatment of the wood will render the wood fibers brittle, is unsuitable.

The general problem may be considered from several points:

(1) THE TIMBER.—The timber used for paving blocks should be sound, well-seasoned, even-grained and of at least a moderately slow growth. It has been found by experience that the very hard dense woods do not wear as well, or take treatment so freely, as the softer and more porous timbers. It was formerly thought that long-leaf yellow pine was practically the only wood suitable for such work, but it is now believed that other woods, such as tamarack and southern black gum, are suitable. The point to be emphasized, however, is that all the timber on one job should be of the same kind, in order that inspection may be made simpler and the blocks uniform. Rigid inspection of the timber before treatment with the oil is necessary, for some of the companies have at times been accused of substituting inferior woods for the one specified, and it is practically impossible to detect substitution after treatment.

(2) OIL.—This subject has probably aroused more discussion and disagreement among engineers than any other. Manufacturers using various processes have very naturally advocated their own product to the exclusion of any other, and the engineer who has not had the opportunity to study this matter in detail is soon over-

*Civil and Sanitary Engineer, 125 La Salle St., Chicago.

whelmed by a mass of apparent contradictions. The life of the pavement is very much dependent on the character of the treatment, the wear of traffic being excepted, and hence this is a most important point to consider. It is simple folly to assert that the amount of oil suitable for one location is necessarily proper for another, many miles away, under different conditions of climate, traffic, timber, etc. Twelve pounds of oil may be right and proper in Chicago, on State St., and absolutely useless on a quiet residence street of a small city hundreds of miles away.

It is now generally recognized by engineers familiar with such work that dead oil of coal tar, carefully distilled under rigid inspection, is the best preservative. Mr. Richard Lamb, M. Am. Soc. C. E., in his discussion of the writer's paper on "Paving Practice in Chicago" before the American Society of Civil Engineers (Trans. Am. Soc. C. E., Vol. LXVI., pp. 43-48) and in his discussion of the paper by Walter Buehler, M. Am. Soc. C. E., on "Timber Preservation" before the same society (January Proceedings, 1911) very clearly and ably handles this subject and points out many mistakes made by engineers and others. Napthalene and anthracene appear to be the main germicidal constituents of the creosote oil.

Mr. John B. Hittell, M. Am. Soc. C. E., Chief Engineer of Streets, Chicago, had some experiments made in 1908 as to the volatility of oil then used in Chicago for treating wood blocks. He found that the blocks so tested lost about 9% of their added oil in three days in the even temperature of a closed room. It is evident that such oil was not of good quality and that the city of Chicago was not getting proper oil for preserving the blocks. As a result of such experiments and other investigation, the specifications were made to read that the oil used should not volatilize up to 150° C. Later, as shown in Mr. Marr's article before mentioned, this was changed to allow a loss of not more than 2% at 150° C. In the writer's opinion this change was a step backward.

(3) COST, AS COMPARED WITH OTHER PAVEMENTS.—As a general average the prices of the various pavements in Chicago are as follows, all having a foundation of 6 ins. of concrete, and with all inspection rigid:

Brick, $2 per sq. yd.; asphalt, $1.90; creosoted block, $3; granite block, $3.75 per sq. yd.

It will be seen that the wood block is an expensive pavement if properly built, and that if its advantages are to be realized they must be paid for.

(4) CHARACTER OF WORK DURING CONSTRUCTION, INSPECTION, ETC.—In common with all properly-constructed pavements, creosoted wood block requires rigid inspection and care. In fact, there is no other pavement except asphalt that is so technical and difficult. If properly and carefully laid, this pavement can stand much abuse, but if improperly constructed it goes to pieces very rapidly. The foundation should be uniform and smooth, the blocks laid with the greatest care to keep out the many culls which are always present. Special care must be taken to see that the blocks are always laid on the end of the grain, not on the side (a point which is sometimes difficult to determine, as the blocks are black with oil). As few blocks should be cut as possible, as this exposes the untreated heart of the wood. Closures and joints should be carefully made, rolling and tamping the surface to a smooth contour; provision made for expansion at the proper places; great care taken with the drainage; and above all the blocks should be inspected by a thoroughly competent man at the plant before shipment and the amount and kind of preserving oil carefully determined by a chemist. In short, from the time the timber is cut until it is part of the finished surface of the street it requires the most careful inspection and treatment. If these and many other points too numerous to mention are taken into consideration, an admirable result may be obtained.

In the construction of the creosoted wood block pavement, from start to finish, every precaution must be taken in order to get a good result. The blocks cannot be piled on the sidewalks like brick and lay for weeks before being used. A few hours with the hot sun on the raw surface of the blocks cracks them in hundreds of places, and these cracks are sometimes serious. Therefore if it be necessary for the blocks to be stored on the street they must be carefully protected by coverings. This cracking is not evident after the blocks are in the street, probably because they are then protected on three sides and covered on top with dirt and dust.

Again, the blocks should not be laid on a wet sand bed, such as exists after a hard rain. Experience and experiments have both shown that they absorb more or less water accompanied by heaving or swelling. It has been stated that having once heaved the pavement will not again get in that condition. This is a mistake. The writer has observed a number of cases where heaving has taken place repeatedly, and the necessary repairs made, only to heave again. Expansion joints properly placed will take care of this, and a heavy traffic tends to iron it out.

The question of culls is very important. Mr. Marr, in the paper already mentioned, shows very clearly some of the common faults to be looked for, and unless they are searched for vigorously they will escape notice. The culls run from 1% to 10% of the total number of blocks and only the greatest care will eliminate them. One of the most persistent and annoying class of culls is the short blocks. These are blocks that have been sawed slightly shorter (in depth) than the rest, and if they are not culled out they form low spots in which moisture collects to the consequent harm to the pavement.

(5) WEARING QUALITIES OF CREOSOTED WOOD BLOCK.—Statements have been made from time to time that creosoted wood block pavement will outwear granite block. Such statements are discouraging to any one having a real desire to see a meritorious article succeed. In the downtown district of Chicago, there are granite block streets under heavy traffic conditions which are twenty-five years old, and still in good condition, though very noisy. It is expected abroad that in heavy-traffic streets the wood block will wear not more than six or seven years, and then must be renewed. If the traffic is not heavy the life of the pavement will probably be about fifteen years, and then it will begin to rot out. The advantage of this pavement is its noiselessness, sanitary excellence, appearance, small tractive effort required, etc., and not in its exceedingly long life.

Creosoted wood blocks do not wear well when placed between street car tracks, or used as a "brow" on the outside of the rails. This is because most modern car-track systems now have the rails tied to each other by a flat iron tie rod about once in 6 ft., and this makes a wide joint in the blocks. The calk of horses' shoes soon wear this much wider and in a few months the pavement in heavy-traffic streets is in a lamentable condition. On the "brow" the cause of the trouble is two-fold. First, because this is a closure point and hence blocks must be cut, thus exposing fresh surfaces to the action of the elements; and second, because the traffic naturally seeks the tracks and the wheels often follow along the pavement just outside the rail and a bad groove forms which holds moisture and dirt. A granite brow is preferable.

In spite of all statements to the contrary, a pavement of creosoted wood block is always slippery. Horses are frequently seen to fall, especially on a cold day. In this respect it is more faulty than asphalt. In Europe the remedy for this is the spreading of sand on the surface, and frequent applications, together with the traffic, force the sharp sand into the grain of the wood, and alleviate this trouble. However, this pavement is never advisable on a grade greater than 3% or 4%.

Another source of annoyance is the "bleeding" of the blocks in hot weather. The oil and also the tar used as a filler soften up under the sun and exude on the surface of the roadway. The result is extremely disagreeable for pedestrians, and the oily product is tracked on the sidewalks and into hotels and office buildings and causes a great deal of complaint. In the course of two or three years this nuisance passes away. If a grout or sand filler is used it is not so apparent.

The maintenance of all pavements is a most important item in their durability, but this is especially true of creosoted blocks. They belong to the same class as asphalt in this respect. The only way to keep such a pavement in good condition is by constant maintenance. Such maintenance is both cheap and easy, however, and in this respect the pavement belongs in the class of brick or granite pavements. But if the surface is to be kept in good condition it must not be neglected to the same extent that such pavements so frequently are, for the disintegration once started proceeds more rapidly.

Its chief advantages are its:

Cleanliness,
Noiselessness,
Sanitary excellence,
Smoothness,
Small tractive resistance,
Adaptability for repairs,
Pleasing appearance,
Low maintenance charges.

Its chief disadvantages are its:

High first cost,
Slipperiness,
Tendency to swell and heave,
Constant maintenance,
Tendency to "bleed."

It should not be laid on steep grades, between rails or car tracks unless a special block is used, or as a brow pavement. A proper consideration of its cost and life puts it under a decided disadvantage on streets of moderate traffic in residence districts in comparison with sheet asphalt, and until the price is reduced to approximately that of asphalt, the writer believes that its proper place is on business streets where the value of the property is such that it can equitably stand an assessment for repaving every eight or ten years, in consideration of the quietness and comfort secured by its use.

THE RELATION OF SEA LETTUCE TO SEWAGE disposal at Belfast, Ireland, has been investigated in detail by the British Royal Commission on Sewage Disposal, and is discussed at length in the Seventh Report of the Commission, which has just been published. It has been thought for many years past that the green seaweed, popularly known as sea lettuce (*Ulva latissima*) which grows in Belfast Lough and causes great nuisance on the surrounding shores, was largely stimulated by the discharge of sewage into the Lough. In fact it was even supposed at one time that the bad odors were due to the decomposition of solid matters deposited by the sewage itself. Extended studies of this aquatic growth in relation to sewage disposal have been carried on for a number of years past by Prof. E. A. Letts. An abstract of an interesting report on this subject by Prof. Letts appeared in our issue of Oct. 22, 1908, p. 459. Acting on the theory that the seaweed was aided in its growth by the nitrogenous matter in the sewage, Prof. Letts recommended sewage disposal works designed with a view of not only reducing the organic matter in the sewage but also of denitrifying the nitrates in the effluent. To this end he proposed (1) grit chambers; (2) screens; (3) settling tanks; (4) percolating filters; (5) settling tanks again; (6) denitrification, apparently by contact beds. According to an abstract of the report of the Royal Commission, just mentioned, which appeared in "The Engineer" for March 17, 1911, investigations of the Commission have led it to conclude that the cause of the nuisance

is the ulva itself and not the sewage alone. In other words, that the nuisance would be there even if there were no sewage discharged, though perhaps it would not be so marked, because the sewage may increase the growth of the weed. The Commissioners are, in fact, of opinion that no higher degree of purification than that obtained by efficient sedimentation is necessary in the case of Belfast sewage, though it might be wise to provide for the possibility of some further treatment in the shape of chemical precipitation to aid in the sedimentation of the sewage. They, however, express themselves as satisfied that the nuisance cannot be effectively removed by any scheme limited to the treatment of Belfast sewage.

The Commission is also of the opinion that the growth of the sea lettuce is materially aided by the large growth of mussels on the bottom of the Lough which afford anchorage for the seaweed. Experiments with copper sulphate showed that this agent killed both the weeds and the mussels, but that this was effective for only some two months. Experiments with clearing away the mussels showed that this also was but a temporary expedient. The only lasting relief from the ulva nuisance, the Commission believes, would be filling in the shallow waters of the Lough. The weed, it should be stated, grows but slightly in deep water and the nuisance resulting from it is greatest where the bottom is exposed at low water. In justice to Prof. Letts, it should be stated that some time ago he suggested reclamation by filling. The Commission and Prof. Letts also concur in believing that while the filling is being carried out either the ulva and the mussels should be removed so far as possible or else copper sulphate treatment should be used. The Commission also suggests that the dried ulva may be useful for fertilizing purposes.

Sewage Disposal With Respect to Offensive Odors.

Among the many papers presented the second week in April before the Congress of Technology at the fiftieth anniversary of the granting of the charter of the Massachusetts Institute of Technology, held at Boston, Mass., there was a lengthy one on "Sewage Disposal With Respect to Offensive Odors" by Mr. Geo. W. Fuller,* M. Am. Soc. C. E. Although the subject was limited as indicated by the title, the paper touched at least briefly on nearly all phases of sewage purification. After a few opening remarks the author said:

It is scarcely possible to install sewage disposal plants to serve large towns and cities without there being some noticeable odors and smells immediately at the plant. These odors, however, at some plants are not, and indeed if the works are properly built and operated should not be, offensive. Even at the works themselves the odors should never be as noticeable as the odors emanating from some fertilized lawns or industrial establishments.

On the other hand, it is unfortunately true that some sewage disposal plants have been ill-y arranged as regards location and design, and that some of them have been poorly operated. The result has been that in some places objectionable odors undoubtedly have arisen, and in consequence the offensive smells from such plants have been used with much force as arguments by land owners who for sentimental reasons protest vigorously against disposal works being built within several miles of properties in which they are interested.

Many anomalous conditions of a complicated nature have arisen recently in America with respect to sewage disposal projects. In nearby communities litigation and legislation have been directed to diametrically opposed propositions. Thus the contests are instituted in some instances to compel, and in other cases to prevent, the installation of disposal works; while elsewhere they relate to efforts to remove plants from the outskirts of a town or to the converse; that is, to preventing an isolated site being adopted if it happens to be near some land owner of especial influence.

The question of offensive odors is but one feature, but it has been a bothersome one in some instances where persons have persistently exaggerated the shortcomings of some plants and converted the exceptions into the rule as regards sewage disposal experiences.

Regardless of the unreasonableness and selfishness with which the opponents to sewage disposal sites in their neighborhood may present their cases in some instances, it seems to be clear that those having to do with sewage disposal works must increase their efforts towards building plants free of nuisance as to offensive odor when operated properly, and furthermore to see to it that plants are operated in such a manner that there is no just ground for complaint from residents in the neighborhood of such works which at best are open to sentimental prejudices.

Putrefaction of Sewage.

After discussing the composition of sewage and other matters relating to purification the author took up putrefaction and its products and means of avoiding the offense due to the latter. Direct and indirect chemical reduction of organic matter were treated briefly, as of comparatively little practical importance, and then direct and indirect biological reductions of organic matter was taken up, as follows:

DIRECT BIOLOGICAL REDUCTION.—This is a large and important field which is full of significance in the operation of sewage disposal works. Our understanding of the subject has progressed quite slowly on account of its very complicated nature. It deals, of course, with the broad field of putrefaction, such as studied years ago by Pasteur in such a brilliant fashion in other fields of research.

We know that as soon as bacteria practically exhaust the oxygen in a sewage, there are plenty of kinds of bacteria that will proceed upon an anaerobic basis to reduce the organic matter to simpler compounds. The result of this represents a complex situation because, in addition to certain products of putrefaction that are quite well known, there are also left in the sewage other residual products about which our understanding is at present quite meager.

Investigations made by the writer at the Lawrence Experiment Station and given in the report of the Massachusetts State Board of Health for 1894, p. 461, indicate that the direct biological reduction of organic matter in sewage relates to dissolved organic matter more particularly than to suspended organic matter. Whether or not these Lawrence tests are representative of a wide range of conditions can scarcely be told from the available evidence. It is a point worth further study.

Cleavage products are characteristic of putrefaction through bacterial decomposition. Marsh gas or methane is, of course, a conspicuous product of the decomposition of vegetable matters as found in the ordinary mill pond, and, is likewise conspicuous in the decomposition of sewage. Some forms of carbonaceous matter, notably the carbo-hydrates, allow carbon dioxide to appear as a cleavage product, and so far as this end-product is concerned there is a similarity between oxidizing and reducing fermentations of organic matter. It is not this product, however, or such decomposition gases as marsh gas, nitrogen or hydrogen, that is related to objectionable odors.

Hydrogen sulphite has the reputation of being the most malodorous product arising from the putrefaction of sewage. It is certainly the best known of the malodorous products, and no doubt it deserves for the most part the reputation which it has received. While this product seems to separate as a cleavage product from the organic compounds containing sulphur, it likewise appears, as already indicated, to be characteristic both of oxidizing and reducing fermentations. Its appearance is obscured, however, in an oxidizing fermentation, on account of its being promptly oxidized.

Sulphureted hydrogen appears to come for the most part as a cleavage product from organic matter, yet in some of the most conspicuous instances of its development it appears to come in part as a result of the reduction of mineral sulphates. In other words, desulphurization through bacterial agencies may be a most important factor to be reckoned with. In some measure it is similar to the denitrification process as affected by bacterial agencies, although it is believed to be of much less frequent occurrence. It is not, however, these bacteria generally spoken of as sulphur bacteria which desulphurize the mineral sulphates. The true sulphur bacteria will live upon sulphureted hydrogen and oxidize it to metallic sulphur. On the other hand, there are several species of bacteria which are capable of reducing mineral sulphates to sulphites and some species which carry the reduction to the sulphureted hydrogen stage. These are a class of bacteria about which more information is urgently needed.

It is not to be inferred that sulphureted hydrogen is the only objectionable product as to bad smells which arise from sewage decomposition. Although our knowledge is very meager as to other products, they undoubtedly exist. Among such a list may be included mercaptan, indol, skatol, cadaverin, etc. It is highly desirable to have more definite information about these last named products from the standpoints of their relation to objectionable smells.

Ordinarily, these products appear in the soluble rather than the gaseous state, but this does not mean that they will not volatilize so as to make noticeable smells in the immediate neighborhood of disposal plants.

INDIRECT BIOLOGICAL REDUCTION.—There is no doubt that enzymes or the soluble ferments secreted by bacteria are an important factor in the reducing decomposition or putrefaction of organic matter in sewage. This is a wide field for laboratory men to investigate under the conditions found in practice. It relates, in fact, most intimately to the question of utilizing to best advantage the so-called septic process. It would appear, according to the writer's observations, that the time interval necessary to establish the septicization may be largely accounted for by the period required by the bacteria to produce the enzymes in sufficient quantity to effect a substantial decomposition of suspended organic matter. When these products become established, however, they proceed in a most active manner and accomplish the liquefaction of organic matter. It seems that these soluble ferments will do their work over and over again for some time without material exhaustion provided they can work in an environment where toxins or other antagonistic products do not arise through their own activities.

PRODUCTS OF PUTREFACTION IN THEIR RELATION TO OBJECTIONABLE SMELLS.—Of the soluble but easily volatile products of decomposition, such as mercaptan, indol and other compounds mentioned above, there is too little information now available to allow anything specific to be said on that score. But as regards the gaseous products of decomposition and especially sulphureted hydrogen there is considerable information that ought to be applied to sewage disposal plants in a somewhat more scientific and reliable manner than is frequently the case under present conditions of practice.

Brief mention will be made of some of these features in order to accentuate to the engineers their importance in practical undertakings as well as to suggest to the laboratory men that there is considerable important work for them to do in securing needed data for crystallizing our views as to the proper handling of these subjects.

In the first place, it will be well to point out some of the physical characteristics of those gases which are related to sewage decomposition, although sulphureted hydrogen is the only malodorous one of the group. A comparison of the characteristics of this gas, however, with others found in the decomposition of sewage will tend to accentuate the characteristics of the gas. Particularly, it is important to note the density and relative diffusive power of the gases and the volume and weight of the gases necessary for saturation under different conditions of temperature and pressure.

At this point, the author inserted three tables giving data regarding various gases of sewage decomposition, including variations according to both atmospheric and water pressure. Mention was made of the fact that sulphureted hydrogen and other gases may accumulate within the sludge at the bottom of a settling tank and rise quickly to the surface of the supernatant liquid. It is also stated that aerial nuisances from sewage works "vary much with the barometric conditions and wind velocity, as they affect the dispersion and oxidation of gases in the atmosphere."

A number of suggestions were given regarding prevention of the formation of odors within sewage-collecting systems. These included warnings as to the importance of sewer ventilation, the desirability of omitting house-connection traps, the need of non-subsiding velocities of sewage flow, smooth interior surfaces and the provision of flushing facilities. As to the latter, the author stated that from the bacterial standpoint "it would probably suffice to have flushing done once a week during the cold season of the year, and, say, twice a week in the warmer season of the year."

Guarding Against Odors.

The balance of the paper was devoted mostly to guarding against odors in sewage-disposal works.

DILUTION.—Taking up the required degree of dilution in the case of disposal into water without treatment, mention was made of the recommendation submitted in 1887 by Mr. Rudolph Hering for a dilution of 3⅛ cu. ft. of water per sec. per 1,000 population connected with sewers as a basis for designing the Chicago Drainage Canal. On the whole, this appears to have given satisfactory results, although there are indications that a higher degree of dilution is needed for trade wastes, particularly those from the Chicago stock yards district. Considerably later, the engineers of the Massachusetts State Board of Health laid down for guidance under different conditions a range of dilution from 3½ to 6 cu. ft. per sec. per 1,000 population connected with sewers.

DISPERSION.—Particular attention must be paid to the design of outlets to secure proper dispersion where reliance is placed on disposal by dilution. Likewise, it is necessary to guard against the formation of sludge banks, floating solids and grease and scum, but, broadly speaking, when these problems arise the author would naturally recommend some means of purification.

KILLING FISH.—Offensive smells due to the killing of large numbers of fish have been caused through sewage disposal in some instances. The author states that "available evidence indicates that ordinary major fish may be reasonably provided for when the dissolved atmospheric oxygen in the body of the diluting water does not become less than 33% of that necessary for saturation." In this connection the author states that a recent suggestion that a margin of 75% of residual dissolved oxygen should be insured "is seriously in error as an unqualified general proposition."

GRIT CHAMBERS.—Coming next to the removal of suspended solids in sewage from the viewpoint of prevention of odor, the author first mentions grit chambers. A reasonable velocity in these is 6 to 12 ins. per sec. The main point, of course, is to prevent the accumulation of the lighter organic matters with the heavier organic grit. The use of screens in connection with filtration plants, and particularly fine screens, presents questions which cannot yet be finally answered. "For large plants," the author says, "mechanically-operated screens have a considerable field of usefulness." The judicious use of scum boards may sometimes be preferable to the use of screens.

Sludge Disposal.

The "sludge disposal question," the author states, "is by far the greatest single problem in connection with sewage purification." Sludge

*Consulting Hydraulic Engineer and Sanitary Expert, New York City.

beds are usually unsatisfactory for large plants, and where used "with moderate success" their operation is usually confined to the cooler seasons of the year, when the sludge may become thoroughly dried and removed before warm weather sets in." Burial of sludge in trenches has merit for small plants, especially in northern climates, but for large plants cannot compete with Emscher or Imhoff tanks.

Septicization in one-story and in two-story tanks is next considered. By one-story tanks the author, of course, means the old type of septic tanks, and by two-story, either the Travis or the Imhoff tank. Attention is called to the fact that certain claims in the Cameron Septic Tank Patent (No. 634,423) were upheld several years ago by the U. S. Supreme Court, but that the termination of the life of the patent is still in the court under another suit, the question at issue being whether the American patent terminated with the British in November, 1909, or whether it was extended by the International Treaty of Brussels to Oct. 3, 1916.

The advantages and disadvantages of the single-story or original-form septic tank were discussed by Mr. Fuller, but since he comes out strongly in favor of the two-story (Imhoff or Emscher) tank, it seems unnecessary to report what he says about the old-style tank. Mr. Fuller's remarks on the two-story tanks are given in full.

Septicization in Two-Story Tanks.

These tanks have recently been referred to as the Imhoff or Emscher tanks. They have their origin from a scientific standpoint in certain tests made a dozen years ago by Mr. Clark at the Lawrence Experiment Station in the septicization of sludge in compartments separate from the sedimentation tank itself. These studies resulted as a first practical outcome in the so-called Travis hydrolytic tank at Hampton, England. These tanks have horizontal partitions or baffles which separate the upper sedimentation chamber from the lower digestion chamber in which septicization takes place. The partitions have a steep slope which allows the deposit or sediment to slide through a slot at the bottom into the digestion chamber substantially as fast as it appears in the sedimentation chamber above. The lower edge of one of these partitions extends beyond the edge of the other partition. In this way the gas resulting from the septicization in the lower compartment cannot pass vertically into the digestion chamber, but makes its escape through vents at the side. The principal difference between the Travis tank and the Imhoff or Emscher tanks is that in the former a certain portion, say 20% or so, of the sewage passes regularly through the digestion chamber. In the Imhoff tank, however, none of the contents of the digestion chamber are allowed to mingle with the effluent of the sedimentation chamber above.

These two-story tanks seem to possess all the advantages of the single-story tank and especially are they superior in that they allow a settled effluent to be obtained which is substantially as fresh as the unsettled sewage reaching the plant. In other words, a settled sewage is obtained which is at all times free from the results of septicization as to putrefactive products and the sludge of the digestion chamber. The sludge is freed from the sedimentation basin automatically and continuously, and it is not necessary in removing the digested sludge to deal with a sedimentation chamber full of fresh sewage, perhaps with more or less scum upon it. In brief, it is possible to obtain a sludge which in a suitably designed tank has remained in the digestion chamber for a sufficient number of months to become so thoroughly rotted out that it is well humified and quite inodorous. Furthermore, a sludge can be obtained under ordinary circumstances from these deep tanks such that its removal and its separation from water is much easier than with ordinary septic tank sludge. The deep tanks under the conditions as tested for some three years or so in the Emscher district of Western Germany seem to be unusually free from odor compared with the single-story tanks or even two-story tanks, in which some sewage constantly passes through the digestion chamber. This seems to be due to a number of factors, among which may be mentioned the greater coefficient for the absorption of gases by liquids under a greater depth and pressure, and also the mixing which seems to take place. This mixing seems to promote the absence of large bubbles rising vertically so as to make their escape into the atmosphere of the surface. Perhaps the latter is also due in part to the additional opportunity afforded for combination of gases with the liquid in the chamber.

The disadvantage of septicization in two-story tanks is that the tanks are more expensive and difficult to build than one-story tanks, particularly if the lower portions are to be built in rock, ground water or quicksand. The scum of floating matters on the surface of the liquid in the sedimentation chamber requires frequent and careful attention to guard against odor. Under some circumstances this may be true of the scum which appears on the surface of the gas vents connecting with the digestion chamber. The sludge cannot be removed and dried on thin gravel beds in an advantageous way during the severe winter weather in the northern climate, and hence under some conditions it is necessary to build digestion chambers that are very large. The process does not prevent sulphureted hydrogen formation in the sludge, but with good management it seems to minimize the escape from the digestion chamber of objectionable gases in the surrounding atmosphere.

Taking everything into account, it may be said that the treatment that is most suitable and available to-day to secure the above requirements is that of the two-story tank in which sedimentation occurs in the upper chamber and the digestion of the sludge in the lower compartment with no connection between the two for transmitting gases or other products from the lower to the upper. In the opinion of the writer, it constitutes the greatest step in advance that has been taken in the field of sewage disposal during the past five years. This opinion is given with full appreciation of the fact that the process is one that requires careful management and that there is a large amount of work to be done by the chemist and bacteriologist in adapting it so as to work to best advantage under a wide range of differing local conditions.

This process, like practically all others, is not a "cure-all" for various conditions without careful management. There is no reason to believe that sludge digestion by this process does not involve sulphureted hydrogen and all other malodorous products. Available data clearly indicate that these products are formed. The problem is to control them as well as or better than they have been controlled in the several score of plants that have worked so well in the Emscher district in Germany. In some measure the Emscher results have been associated in the minds of some with iron compounds which precipitate the sulphureted hydrogen, and which may perhaps have much to do with the texture and condition of the sludge, as regards its rate of drying on strainers of coarse sand or gravel. It also may be that the mixing which occurs in the digestion chamber, due to gas ebullition, may be of much benefit, and that this may be controlled under some circumstances to advantage by artificial mixing with aid of water introduced under pressure, as has been done in some instances in the Emscher district.

There is no reason why the artificial application of iron salts should not be availed of in well-managed plants if needed. With this done, a large share of the difficulties encountered in some plants could be overcome as regards the objectionable odors encountered from time to time.

Filtration Processes.

Intermittent sand filtration, contact beds and sprinkling filters are each briefly discussed in the paper. As to filtration processes in general, Mr. Fuller says:

> When a sewage has been well clarified under such conditions that it has been kept as fresh as possible, that is, with bacterial decomposition on an oxidizing and not on a reducing basis, and where the sludge has been taken care of in an inodorous way, it is not a difficult matter to filter the sewage by one of several different methods so as to secure a non-putrescible effluent of good appearance without objectionable odors.

INTERMITTENT FILTERS.—With intermittent filters, the chief need to be guarded against for the prevention of objectionable odors is clogging of the surface, with resultant ponding of the sewage so that it will putrefy.

CONTACT BEDS.—With contact beds higher rates may be maintained by applying sewage when fresh by using coarse stone that will drain quickly and by beginning to drain shortly after the pores of the bed are filled. There is also material advantage in filling the bed from below and keeping the sewage a few inches beneath the surface. This obviates possible odors from either the sewage itself or from scum forming on the surface of the bed, and also renders scraping of the surface unnecessary. The author adds that under-fed beds should have false bottoms and should be drained at sufficient velocity to flush out solid matters deposited on the filter floor. Ordinarily, too, under-fed beds call for final settling basins, but evidently the author has more particularly in mind the need of such basins where the effluent is to enter a small stream or is to be applied to a sand filter working at a high rate.

SPRINKLING FILTERS, if dosed with sewage in a putrefying condition, release "various malodorous products, particularly the sulphur compounds," but if the applied sewage is fresh sprinkling filters seldom give odors noticeable 200 ft. away.

RELATIVE WORKING CAPACITIES.—As to the relative working capacities of the three forms of filters just mentioned, the author says that intermittent sand filters of "fairly porous material and with unsettled sewage" should give good results when treating sewage of not over 600 people per acre; and that for short periods unsettled sewage at even higher rates may be applied, particularly if fairly coarse filtering material is used. Contact beds about 4 ft. deep "will operate satisfactorily" when receiving sewage at the rate of 600,000 gals. per acre daily [6,000 people?—Ed.] provided the sewage has had "some clarification." Sprinkling filters 6 ft. deep will ordinarily dispose satisfactorily of the sewage of some 20,000 to 25,000 people per acre. This is predicated on the conditions being such that the atmospheric oxygen is present at all times and at all places within the pores of the filter bed. The filtering material should not be too fine, as otherwise there is danger at intervals of surface clogging, due either to suspended matter in the sewage or to filamentous vegetable growths or both. With reference to the size of the material, that most generally preferred is either from 1 to 2 ins. in average size, or from 1½ to 2½ ins.

The relatively small portion of the paper remaining may be given in full as follows:

DISINFECTION.—Where sewage is discharged into drinking water, streams or bodies of water from which shellfish are obtained, it is possible and sometimes advisable to destroy at moderate cost the vast majority of disease-producing germs in the sewage by applying strong oxidizing chemicals, such as hypochlorite of lime or soda. This treatment scarcely provides absolute sterilization, as it is obviously out of the question at moderate cost to destroy by oxidation the thick-walled spores or even the vegetative bacterial cells that are encased in particles of suspended matter. It is feasible, however, to destroy more than 99% of the vegetative cells which respond to ordinary laboratory methods of enumeration.

Several investigators have noted that when sewages or sewage effluents are treated with a sterilizing chemical the liquid will not putrefy for some time. This is explained in a large measure by the death of bacteria, which are capable of decomposing the sewage and thus setting up putrefaction after available oxygen is exhausted. Even when such samples are mixed with surface waters of good quality a comparatively long period may elapse before they putrefy. This may be explained in part by an excess of the sterilizing chemical which may destroy the bacteria of the water which is mixed with the treated sewage or sewage effluent. It may also be explained in part by the failure of the diluting water to contain bacteria which readily bring about a reducing fermentation or putrefaction.

It is not to be inferred, however, that sterilized sewage may be discharged with impunity into small watercourses, particularly if there is considerable suspended matter in the treated product. It would be only a question of time before the suspended matter would deposit and form sludge banks in which bacterial putrefaction would become established. It is also probable that sterilized sewages or sewage effluents, regardless of the suspended matter, would sooner or later putrefy in its flow in a water-course by mingling with the surface waters containing bacterial flora that would set up putrefaction.

Reflection upon the comments above made will be of assistance in understanding the practical application of bacterial processes of oxidation and putrefaction in that they show that it is necessary to have time, bacteria and oxygen to bring about an oxidizing fermentation; and, further, that it is necessary to have the right kinds of bacteria, the necessary amount of time and absence of oxygen to bring about putrefaction. Sewage will not putrefy if all three factors are not provided, and this also explains why oxidation even of crude sewage will continue for an abnormal period when the oxygen is increased by aeration and thus postpone the time when putrefaction arises.

The purpose of this paper is largely to outline the writer's present understanding of the scientific status of oxidation and reduction as these products occur in sewage treatment. This has been done, partly with a view to promoting appreciation of the subject by those who are not specialists in this field, and partly to indicate where more data are required.

As to the practical art of sewage disposal, the methods now available permit much more satisfactory results to be obtained than was the case a few years ago. Those causes, which from time to time in exceptional cases have resulted in unsatisfactory conditions, with objectionable odors now and then noticeable at some distance from the disposal plant, are now quite well understood. Consequently, there should be in the future far less opportunity than at present to cite instances where modern sewage disposal works with good management fail to eliminate nuisances, but tend to create them.

Reducing Motions for Steam Engine Indicators.

By JAMES A. SEAGER,* Assoc. M. Inst. C. E.

The length of steam engine indicator diagrams is, in modern practice, about 4 ins., and seldom if ever exceeds 6 ins. As engines are sometimes built with a piston stroke exceeding 7 ft. some form of reducing gear is necessary to keep the diagram within the limits of the indicator travel. It is proposed in the following article to discuss some of the various methods which are used for this purpose. The earliest method used, and one that still finds a considerable amount of favor, is an arrangement of links which gives a more or less accurate copy of the motion of the cross-head, generally in a direction parallel to its motion. A cord is led from the reducing motion over one or more pulleys to the indicator. Some of the more usual forms are shown in Figs. 1 to 5. In each of these figures, *C* is the point of attachment to the cross-head, *F* that to the framing and *O* is the pin for the cord.

Of these the pantograph is the type. It was

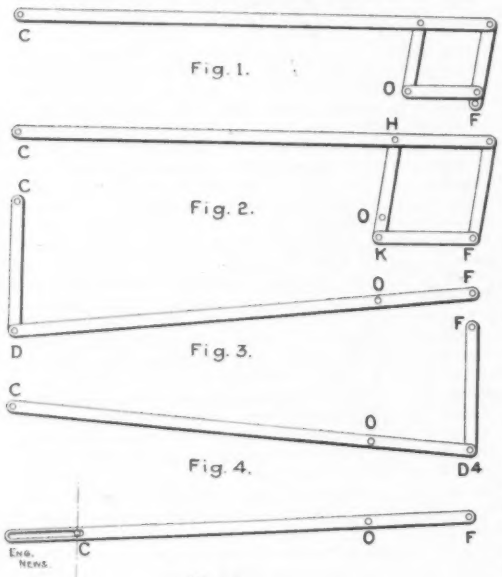


Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5.

Figs. 1 to 5. Indicator Reducing Motions of the Lever Type.

much used at one time in one or other of the forms shown in Figs. 1 and 2, the arrangement of Fig. 2 having the advantage of possessing one pin joint less. It gives theoretically a perfect copy of the motion of the cross-head, but in practice it suffers under two disadvantages: the ratio of the length of diagram to the piston stroke is not easily adjustable, and the wear of the numerous joints causes the mechanism to lose its original accuracy in a short time. Hence most of the reducing gears of the pantograph type which are now used are designed to give only an approximate copy of the motion of the piston, but, having few wearing points, they retain their original accuracy for some time.

The linkages shown in Figs. 3 and 4 are among the most commonly used and when well designed they are hard to beat for accuracy and reliability. Both are simplifications of the pantograph. A consideration of Fig. 2 will show that the motion of the point *K* is similar to that of *O* in Fig. 3, while the motion of *H* is similar to that of *O* in Fig. 4. The conditions for maximum accuracy are that the lever (*FD* or CD_4) should swing through equal angles on either side of a line at right angles to the motion of the piston, while the link should swing equal distances on each side of a line parallel to the piston rod. In addition, if a short adjusting lever, or a sector of a pulley be not fitted, the cord should pass to the indicator parallel to the piston rod and on the same side of the lever as the link.

A type of reducing gear that is sometimes seen, but which should never be used—unless perchance one is selling engines at so much per indicated horsepower—is that of Fig. 5. The effect of this gear is to make the reduction at the ends of the stroke greater than in the middle. As the ordinary indicator diagram is "fatter" in the middle than at the ends the result is that the mean pressure thus obtained is greater than it should be. This effect is shown in Fig. 6, where the true diagram is shown in full line and the distorted diagram in broken line.

To obtain an accurate motion the pin *O* should be guided parallel to the piston rod and should slide in a slot in the lever. If this gear is already fitted to an engine and it is not considered desirable to scrap it, the expedient shown diagrammatically in Fig. 7 may be used. The pin *O* is replaced by a bar, at right angles to the lever, carrying two small pins *M* and *N* spaced apart a distance equal to the length of the diagram. The cord is attached to the pin furthest from the indicator. At half stroke of the piston the cord is just touching the pin nearer the indicator. Thus during one-half of the stroke of the piston the indicator is operated from the first pin and during the other half of the stroke from the second one. This arrangement gives a movement that is correct at the ends of the stroke and the middle and has only a slight error at any other point. It is, however, clumsy and requires careful adjustment and it is not recommended except as a makeshift.

In the case of enclosed high-speed engines, the development of the indicator reducing motion has proceeded along different lines. Owing to the high accelerations used in these engines the ordinary types of indicator gear would wear very rapidly if left continuously in action, while, if dismantled, the engine would have to be stopped and the crank chamber opened when it was desired to obtain diagrams. Hence generally a lever is used which is held in contact with the operating part by a spring but which may be drawn back and held out of action by a catch when not required. One form is shown in Fig. 8. In this sketch, which does not represent any particular make, an inclined blade or skate is attached to the engine cross-head and the end of one arm of the bell-crank lever is held in contact with it by a spring. The spring and the catch for holding the lever out of action are not shown. Sometimes the lever is entirely outside the crank chamber and is operated by a plunger as in Fig. 9. This device gives a very accurate motion provided the cross-head is not slack and knocking in the guides.

In Fig. 10 a form operated by a small eccentric on the crank shaft is shown. The small eccentric is generally bolted to the side of the valve eccentric sheave and the roller at the end of the lever is held in contact with it by a spring. As this is a separate mechanism it cannot be said to give a copy of the movement of the piston, but if the sum of the radii of the eccentric and the roller bears the same ratio to the throw of the eccentric as the length of the connecting rod bears to the throw of the crank, the motions are exactly similar.

A very ingenious example of this method of reproducing the movement of the piston by a separate mechanism is the Graham patent non-stop gear, manufactured by Messrs. Schaeffer and Budenberg, of Manchester, England. The gear is shown in Fig. 11, which is almost self-explanatory. The pin *A* is screwed into the shaft end and drives the crank disk *H* by means of a pin *B* which fits a single hole in the adjacent collar. The handle *S* operates the catch *T* so as to enable the gear to be fixed either in or out of action. The middle disk in the end elevation, to which *T* is hinged, together with the guides *M* and *N*, constitutes the stationary part of the gear and represents the engine framing; it is attached to any convenient part of the engine at *E*. The gear may thus be easily adapted to any engine or series of engines, and provided that the pin *A* is already in the shaft end the gear may be fitted very quickly without stopping the engine.

Reducing Wheels.

The reducing wheel is another comparatively modern form of indicator reducing motion. It consists, in general, of two wheels so connected that one is driven by a cord connected direct to the cross-head while the other drives the indicator by a second cord, the reduction being obtained by gearing and by a difference in the sizes of the pulleys. These wheels have the great advantage that there is no indicator gear on the engine. All that is necessary is a pin on the cross-head to which to attach the cord.

A further development is that of the Ashcroft Co., in which a reducing worm gear is combined with the indicator and forms the drum drive.

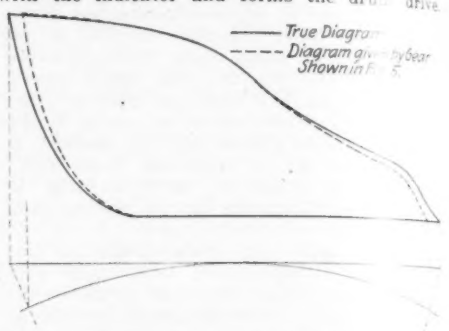


Fig. 6. Erroneous Diagram Given by Slotted-Lever Motion Shown in Fig. 5.

Only one cord wheel is used, attached to the worm shaft.

Hitherto no mention has been made of the inaccuracies likely to be introduced by the stretching of the indicator cord. This stretching is regarded by some authorities as likely to cause appreciable error; and sometimes, when great care was being taken, the cord has been replaced by wire except in such places as it passed over pulleys.

It is obvious that if the stretching of the cord attached to the indicator drum, due almost entirely to the inertia of the moving parts, is worthy of consideration, it becomes of great importance in the case of the reducing-wheel cord traveling at piston speed. It can be shown, however, that any errors so introduced are not of a serious nature from a practical point of view, as is evidenced by the fact that the use of reducing wheels seems to be steadily gaining ground.

The linear acceleration of the cross-head, assuming for a moment that the cord is inextensible, corresponds to angular acceleration of the drum on which the cord is wound. This angular acceleration is of course due to torque which may be expressed as so many pounds pull on

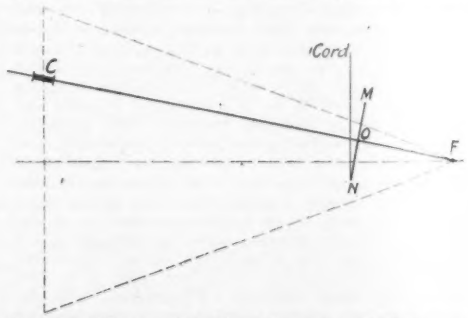


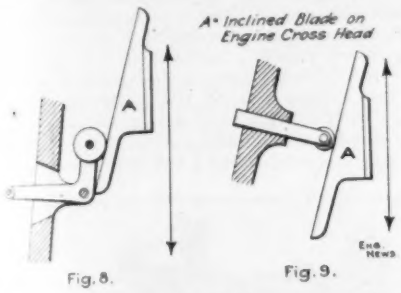
Fig. 7. Diagram Showing How the Slotted-Lever Motion Can Be Approximately Corrected.

the cord at the rim of the drum. Hence the diagram representing the pull on the cord due to the inertia of the drum and its attached parts is identical in shape with the ordinary piston acceleration diagram. If Fig. 12 be such a diagram and if *AE* and *BF* represent the pull on the cord, due to the spring at the ends of the stroke, then any ordinate such as *ab* will give the resultant pull on the cord at that point of the stroke. In the case shown the pull is almost constant and no error is introduced. Should the speed of the engine be changed, this no longer holds, but if *CD* is not much curved the rate of change of tension in the cord is practically uniform.

On the assumption, which is justifiable in the case of a cord that has been some time in use, that the stretch of the cord is proportional to

*Emerson Chambers, Blackett St., Newcastle-on-Tyne, England.

the pull on it, the effect will be in general unimportant. The curvature of the line *CD* is due to the obliquity of the connecting rod and its variation from the harmonic line *GH* is inversely proportional to the length of the connecting rod



Figs. 8 and 9. Reducing Motions Used With Enclosed High-Speed Engines.

and directly proportional to the square of the engine speed. Hence in the case of engines with low or moderate piston speeds, and with connecting rods not unduly short, the reducing wheel gives trustworthy results.

An Automatic Alternating-Current Block-Signal System for Steam Railroads.*

On many steam roads having trolley lines in close proximity it is frequently found that the return current of the trolley line will follow the rails of the steam road and if the steam road is using a signal system of direct current track circuits, constant care must be used to prevent the stray trolley current from affecting the relays of the signal system and causing them to give a false indication. The use of alternating current for track circuits effectively prevents any trouble due to stray currents as the relays will not respond to any current except the particular alternating current for which it is adjusted.

What are believed to be the first automatic signals on a steam road, with alternating current for operating and lighting the signals, as well as for supplying the track circuits, were installed on the Cumberland Valley R. R. between Lemoyne and Mechanicsburg, Pa., a distance of seven miles, in 1908, and which have just recently been put in regular service.

Power for operating the system is supplied from a 2,200-volt, 25-cycle, single-phase, alternating-current line carried on poles along the right-of-way, current being obtained from the power plant of the United Electric Co. located at Lemoyne. Lightning arresters are placed at intervals of two miles and trouble from lightning has been confined particularly to an occasional fuse blown out.

Fig. 10. Reducing Motion Operated by an Eccentric on the Crank Shaft.

The small amount of energy used by the 2-candle power electric lamps to light the signal does not justify putting them out in the day time, and the use of electric lights not only avoids the expense of maintaining oil lights, but gives better service in that there is no smoking of lamps and lenses, and light failures are reduced to a minimum.

Transformers are used at each signal location with suitable taps to step the voltage down from 2,200 to 55 volts for operating the signal motor and lights, and five volts for track circuits controlled by suitable resistances. The motors are of the induction type and have no contacts or brushes and no friction surfaces aside from the two armature bearings.

The third or clear position of the signals is controlled without the use of line wires, so that the two main wires are the only line wires used in the automatic territory. Track circuits average one mile with longest circuit 7,000 ft.

No batteries are used on any part of the Cumberland Valley automatic signal system, and the maintenance expense is limited chiefly to the proper lubrication of the signal mechanism, and the care of the rail bonds and insulated joints.

The signals have three positions in the upper right-hand quadrant, normally clear. The operation of automatic block signals of the three-position, upper-quadrant type is as follows. If the line is clear ahead of a train, the signal blades will normally stand in a vertical position indicated by a white light at night, with a red marker light 7 ft. below it and 2 ft. to the left of it, giving it a staggered effect, indicating that it is an automatic signal. If a train occupies the block immediately in advance of a signal the blade or arm will assume a horizontal or stop position, indicated by a red light at night, the following train will come to a full stop at the signal and then proceed carefully, expecting to find a train ahead. If a train approaching the signal finds the blade in the 45° position, indicated by a green light at night, it shows that the block immediately in advance is clear, but that the second block ahead is occupied. Under this arrangement, a train approaching a signal showing a white light is assured of two clear blocks, or in other words, the track is clear for two miles ahead. At an interlocking tower three blades are shown in a horizontal position, and at night three red lights in a vertical position, indicating stop and stay to an approaching train until it receives a clear signal to proceed. If given the top blade, or white light, at an interlocking tower, a train may proceed at full schedule speed; if given the middle blade, or white light, the train will proceed at limited speed, and if given the lower blade, or red light, the train will proceed at low speed prepared to stop immediately.

The operation of these signals has been so satisfactory that a contract was recently awarded for signaling 43 additional miles of double track on the Cumberland Valley, divided into three sections, using alternating current at 3,300 volts, 25-cycle, single-phase, with such modifications and improvements in the signals and equipment as have been made since the original installation. An additional unique feature is carrying sufficient current in the signal mains to supply electric lights at all stations as well as operate the signals. The current supply for this signal and lighting system of the section from Harrisburg to Mile Post 27 will be furnished by the United Electric Co. of Lemoyne; the sections east and west of Chambersburg will be supplied from a power plant owned by the railroad company and located at Chambersburg.

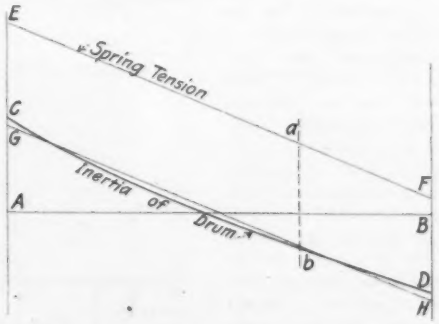


Fig. 12. Drum-Inertia and Spring-Tension Diagram Showing Stress in Indicator Cord.

(The ordinates such as *a-b* show stress in cord, which is nearly constant throughout the stroke.)

*Prepared by Mr. J. W. Lee, Jr., for the Pennsylvania R. R., Philadelphia, Pa.

Results of the Transvaal Stope Drill Competition.*

By R. N. KOTZE.†

The stope drill competition conducted under the joint auspices of the Transvaal Government and the Chamber of Mines was brought to a conclusion during the year. The competition started in May, 1909, and was not expected to last much longer than six months, but difficulties in the way of securing the prescribed pressure of compressed air, namely, the minimum of 60 lbs. per sq. in., prolonged the tests for nearly twelve months. Nineteen machines entered for the tests, but the elimination trials disposed of nine of these entries. Ten types remained to enter the competition of 300 shifts, the drilling being carried out in selected stopes of four mines. As the competition proceeded other machines dropped out and the work in certain stopes was abandoned, the results being finally assessed on the work performed during 215 shifts in five stopes in the Crown Deep, Robinson Deep and Village Deep.

The width of the stopes in which the competition took place varied from 24 ins. to 45 ins. There were two periods done of 43 shifts at an average stope width of 20 ins.; three others at an average width of 35 to 36 ins., and seven at an average width of 36 to 40 ins., this showing that the machines were capable of narrow stoping. It was not the fault of the machines that the whole of the stoping was not done at less than 40 ins., but the mining requirements had of course to be met.

The footage drilled by each pair of the four leading competing machines was as follows:

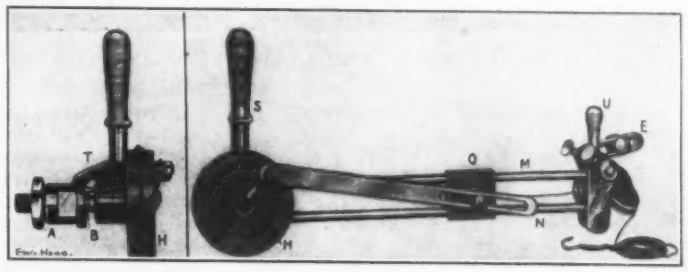


FIG. 11. GRAHAM PATENT REDUCING MOTION.

Holman, 2½-in.	12,779 ft.
Siskol	14,083 ft.
Holman, 2¾-in.	11,744 ft.
Chersen	11,781 ft.

This footage was drilled in 215 shifts of eight hours duration from "face" to "face."

The drilling speeds attained over total time by the four machines are therefore as follows:

Siskol	0.818-in. per minute per machine
Holman, 2½-in.	0.742-in. per minute per machine.
Chersen	0.684-in. per minute per machine.
Holman, 2¾-in.	0.682-in. per minute per machine.

The cost of drilling per foot with these four leading machines amounted to:

Holman, 2½-in.	9.77d. [19.1 cts.]
Siskol	9.90d. [19.3 cts.]
Holman, 2¾-in.	10.91d. [21.3 cts.]
Chersen	11.94d. [23.3 cts.]

In these estimates the cost of drill steel was taken at ½d. per foot drilled and the cost of sharpening at 1d. per foot. The charge for compressed air was made by taking into consideration the air consumption of the machines measured at monthly trials and the average cost of producing and supplying the compressed air on the mines. The charge made for white labor was 5s. per machine shift, this being based on the assumption that one white miner earning £1 per shift should be able to supervise the running of four machines. The charge for colored labor was 2s. 6½d. per shift per native employed, five natives being required for each pair of machines. The charge for stores and spares was the actual cost incurred, and included the depreciation of the machines, which was assessed at the conclusion of the competition.

During the competition it was found that to make up one complete eight hours' machine shift, at an air pressure not lower than 60 lbs. per sq. in., it required about 1.3 mine shifts. If allowance is not made for this, and if white labor is charged at 25s. per shift per pair of machines (which was the price actually paid), the above quoted prices transform to the following:

Siskol	14.1d. [27.5 cts.] per foot drilled
Holman, 2½-in.	14.4d. [28.1 cts.] per foot drilled

The first and second prizes were divided between these two entries.

An important deduction from the competition was that, under suitable mining conditions, stopes could be kept as narrow as required and ground could be broken as cheaply with small machines as with hand hammer boys.

*From the "Annual Report" of the government mining engineer to the Transvaal Minister of Mines for the year ended June 30, 1910. For advance announcements of the competition, see Eng. News, April 16, 1908, p. 428, and July 23, 1908, p. 93.

†Acting Government Mining Engineer of the Transvaal, Johannesburg, South Africa.

Flexible Boilers and Other Special Features of Mallet Articulated Locomotives on the Atchison, Topeka and Santa Fe Ry.

Since the introduction of the Mallet type of duplex articulated compound locomotive in this country, about seven years ago, the very important advantages of this type of engine have led to its extensive adoption by American railways, with a view to economical operation of heavy traffic. Some features of this development and its economic results are discussed elsewhere in this issue.

One of the railways which has gone most extensively into the use of the Mallet engine, and also into the investigation and development of its advantages, is the Atchison, Topeka & Santa Fe Ry. Although its first engines of this type were put in service as recently as the latter part of 1909, it has now 47 Mallet engines in service (two of these being passenger engines and two pusher engines); it has also 12 more of these engines under construction. Furthermore, a comprehensive scheme is being worked out for a still more extensive use of these engines, not only on divisions having peculiar operating difficulties, but also for operating standard 2,200-ton freight trains over the entire line between Chicago and the Pacific Coast.

The first engines (four in number) comprised two engines of the 2-8-8-2 class for freight service, and two of the 4-4-6-2 class. These latter were notable not only for the unusual wheel arrangement, but specially for the fact that they were passenger engines, intended for hauling very heavy through trains at good speed on a division whose profile and curvature were not adapted to the economical handling of such service by ordinary engines. There are also a number of engines of the 2-6-6-2 class, about 40 of these being intended for operating in prairie country where the grades are favorable. A few of these were built by combining two ordinary engines originally of the 2-6-2 class; a larger number were built by taking one of the old 2-6-2 engines and adding to it a new unit consisting of the steam truck and the forward portion of the lengthened boiler. Others, again, are entirely new engines. There are some engines of the 2-8-8-2 class, and a number with a 2-8-8-0 arrangement. Each of these latter engines is composed of a new 2-8-0 front unit added to an old 2-8-0 (consolidation) engine whose truck is removed. A still larger class of Mallet engine, representing the largest, heaviest and most powerful locomotives yet designed, has a 2-10-10-2 wheel arrangement. The leading dimensions of the engines of these different classes are given in Table I. (p. 482), while more complete dimensions of the 2-6-6-2 engines (of which a large number are in service) are given in Table II. A view of one of these engines is shown in Fig. 1.

In many of the Mallet locomotives on this railway special features of construction have been introduced. Prominent among these are the Jacobs-Shupert firebox without staybolts, the Buck-Jacobs superheater and reheater of the tubular drum type, a tubular feed-water heater, and a flexible boiler. The first three of these devices were described in our issues of June 17, 1909, and June 2, 1910. The boiler with flexible joint is described below, with some other features of the latest engines.

Flexible Boilers.

The immense length of boilers on locomotives having from six to ten driving axles would make tube repairs and other boiler repair work very difficult and tedious. A method was introduced, therefore, by which the boiler was made in two units or sections, connected rigidly by a flanged and bolted ring joint. With this disconnected, either section of the boiler could be handled readily. The rear portion included the firebox and the barrel proper or steam generating unit; the forward portion usually included the combustion chamber, superheater, feed-water heater and smokebox. A boiler of this kind, with separable (but rigid) joint was described and illustrated in our issue of April 29, 1909.

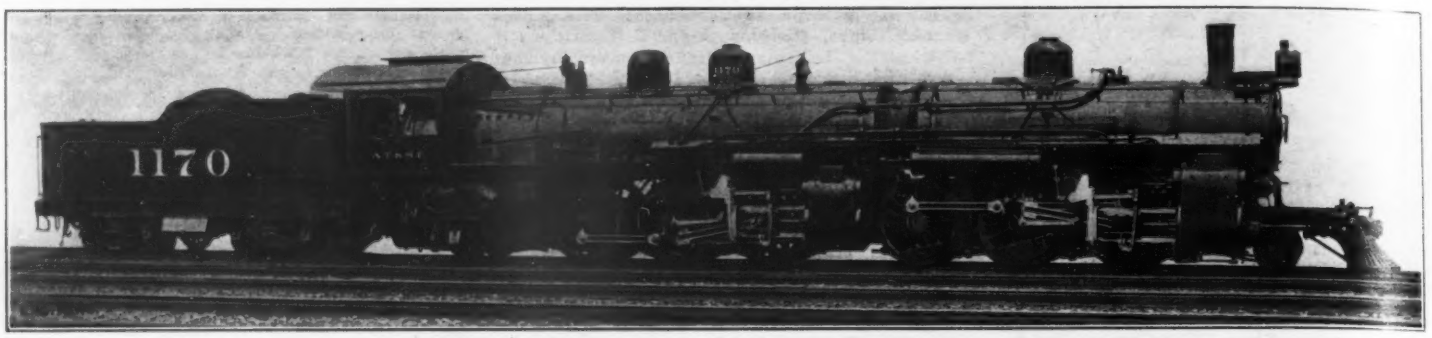


FIG. 1. MALLET DUPLEX ARTICULATED COMPOUND LOCOMOTIVE WITH FLEXIBLE BOILER; ATCHISON, TOPEKA & SANTA FE RY.
Baldwin Locomotive Works, Philadelphia, Pa.; Builders.

While this construction meets the requirements for facility of erection and repairs, it does not eliminate certain difficulties incident to the use of the engine. In the first place, it does not affect the difficulties of adequately supporting the forward end of the barrel on a swiveling truck which has (on curves) a considerable lateral swing relative to the boiler. The truck must have as free a movement as possible, so as to take the curves readily, yet the boiler must be so supported as not to be subjected to racking stresses tending to distort and loosen its joints. In the second place, the very long rigid boiler is liable to cause trouble on the road, due to its great lateral movement on curves causing interference with clearance lines of fixed structures or with rolling stock on an adjacent track.

These difficulties suggested the use of a flexible boiler, formed by the use of a flexible connection at the separable joint. Two engines (2-6-6-2 class) embodying this principle have been built, each having a distinct type of flexible joint. Under this arrangement the rear section is attached rigidly to cross braces or bearers on the rear main frames in the usual manner. The forward section is rigidly attached in the same way to the main frames of the steam truck. This arrangement eliminates the use of sliding supports to permit the truck to swing under the boiler. It is expected to reduce curve resistance and flange wear; and also to give the engine greater stability when on curves, owing to the absence of lateral displacement of the boiler on the truck. In addition to this, there is less complication of the steam piping. On a 16° curve, the two sections of the boiler form an angle of about 176°, instead of forming a straight chord line.

On one of these two engines, the flexible joint is a modification of the ball joints commonly used for subaqueous crossings of water mains, etc. This engine is shown in Fig. 1, and the details of the joint are shown in Fig. 2. The joint consists of two cast-iron tubes or sleeves (A) and (B), somewhat smaller than the boiler shell and of such diameters as to telescope together. One end of each sleeve is formed as a segment of a sphere (C), and is fitted to a corresponding segment (D), bolted to the inside of the boiler shell. The latter segment is made in two pieces for convenience in erection. Packing rings are fitted to the sleeves and to the spherical surfaces; those on the latter are of soft metal and they can be adjusted by means of set screws (F). The telescopic portion forms a slip joint for expansion

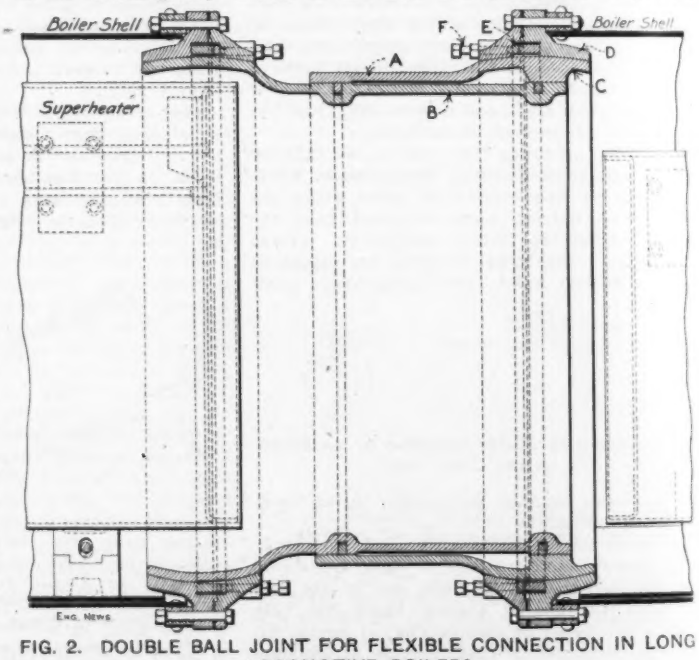


FIG. 2. DOUBLE BALL JOINT FOR FLEXIBLE CONNECTION IN LONG LOCOMOTIVE BOILERS.

and contraction, and the spherical connections permit of the necessary lateral flexibility.

On the other engine, the flexible joint is of the bellows type, shown in Fig. 3. It is composed of 60 rings of No. 14 steel plate, 10 ins. wide and 75½ ins. outside diameter. These rings (A) are slightly dished, so that when assembled they form a series of V's; they are riveted together at the inner contact surfaces, and bolted together at the outer contact surfaces. The flexible tube thus formed is bolted to flange rings (B) on the outside of the two sections of the boiler shell. To protect the rings and rivets from the direct action of the heat and gases, and to prevent cinders from accumulating in the V spaces (thus interfering with the flexibility), the products of combustion are carried through the joint by an inner 44-in. flue (C), having a trumpet-shaped end riveted inside the shell of the rear section of the boiler.

On both engines a centering device is fitted to maintain the two sections of the boiler in proper alinement. The device consists of two heavy horizontal bars, one on each side of the joint, at the height of the center line of the boiler; their ends pass through cast steel brackets riveted to

the two boiler sections. Each end of the bar passes through a coiled spring seated against the bracket; a washer plate on each end of the bar bears against the spring and is held in place by nuts.

In both these boilers the superheater (for live steam) is placed in the rear section of the boiler, while the reheater (for the high-pressure exhaust) is placed in the forward section. These devices are of the Jacobs type already mentioned. It is necessary, of course, to place flexible joints in all pipes which pass the articulated connections in the frames and the boiler, but this does not involve objectionable complication. In fact, the steam piping is said to be simplified, as no flexible joints are required in the exhaust connection between the low-pressure cylinders (on the truck) and the smokebox.

The steam pipe from the throttle is connected to the superheater, the outlets from which communicate with passages cored in the cylinder saddle of the high-pressure (rear) cylinders. Short elbow pipes connect these passages with the steam chests. The high-pressure exhaust is conveyed forward through a pair of horizontal pipes which are fitted with ball and slip joints.

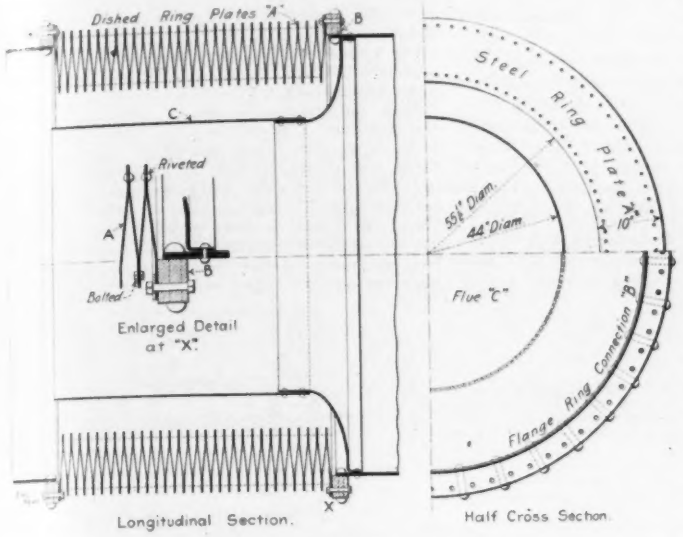


FIG. 3. BELLOWS JOINT FOR FLEXIBLE CONNECTION IN LONG LOCOMOTIVE BOILERS.

They terminate in a cast steel cross brace or waist bearer on the truck, which supports the rear end of the forward section of the boiler. Directly above this bearer is the reheater. The two currents of steam unite before leaving the reheater, and the steam passes out through a pipe on its front end, near the top. This pipe extends through a flue formed in the center of the feed-water heater, and in the smokebox it connects with an elbow pipe leading to a passage in the cast-steel low-pressure cylinder saddle. Short pipe connections lead from this to the steam chests of the low-pressure cylinders. The pipe connections from the steam chests to the smokebox are rigid, and of the usual type.

Other Features of Design.

The two engines with flexible boilers form part of an order for 40 Mallet locomotives of the 2-6-6-2 type, and are practically identical with the others. They are all coal-burning engines, fitted with the Jacobs-Shupert fireboxes and Buck-Jacobs superheaters and reheaters. On 30 of the engines the boiler shell is straight; on the other ten it is of the wagon-top type, with a tapering course to an increased shell diameter over the firebox, thus giving larger steam space. In the latter engines, the rear dome is mounted on the waist or tapering course. The rear section of the boiler contains the firebox, tubular barrel (or steam generator) and combustion chamber. The forward section contains in sequence the smokebox, feed-water heater, combustion chamber, reheater and superheater. In the two flexible boilers, however, the superheater is in the rear section, as already described. The two sections of the boiler (in 38 of the engines) are united by a rigid separable joint composed of two rings on the outside of the shell, held together by 36 bolts 1¼ ins. diameter. The face of one ring is of V section, and that of the other has a corresponding V-shaped groove (Engineering News, April 29, 1909).

The arrangement of the various main and auxiliary portions of the boiler are shown in Fig. 4, which shows also the arrangement of the steam piping for the engines with rigid boilers. There are two domes on the steam generating portion of the boilers; one (A) is just in front of the firebox and the other (B) a short distance from the tube plate. These are connected by two internal 5-in. dry pipes (C). The rear dome is the dome proper or steam receiver, taking steam from the boiler and being fitted with netting to assist in separating water held in suspension. The forward dome has no direct connection with the steam space, but contains the throttle valve (D) and the ends of the dry pipes (C). The throttle takes in steam only at its top, this design being the railway company's standard. With the arrangement described, steam is taken from the most desirable location (near the firebox), the length of outside steam piping is reduced, and all pipe joints beyond the throttle are on the outside of the boiler.

The main steam pipe (E) is fitted to the front of the forward dome, and passes along the top of the boiler to an elbow connection (F) with the superheater (G), this elbow having a ball-joint seat. From each side of the superheater a bottom pipe (H) passes back to the steam chest of one of the high-pressure cylinders. The high-pressure exhaust from each cylinder is led by a pipe (J) to the lower side of the reheater (K). These four steam and exhaust pipes (H and J) pass the separable joint in the boiler shell and therefore each is provided with a slip joint fitted with a packed gland.

After passing through the reheater, the steam enters a flexible receiver pipe (L); this has a vertical slip joint in its connection with the reheater, and around this joint the pipe can rotate as the truck swings to either side. Beyond this swivel joint, the horizontal portion of the pipe has first a slip joint and then a ball joint, the latter being seated upon one of the cross bearers. These three flexible connections provide for all variations in the relative positions of the boiler and the steam-truck frames. The receiver pipe (L) extends forward to a steel box casting to which the low-pressure cylinders are bolted; passages in this casting lead to the two steam chests. The low-pressure exhaust is conveyed forward in two pipes which are bent to meet at (M) in front of the cylinders and connect with a single return pipe (N) leading to the exhaust nozzle in the smokebox. This pipe is fitted with both slip and ball joints to provide the necessary flexibility of the connections. The slightly different arrangement in the engines with flexible boilers has been described above.

Piston valves are used, the high-pressure cylinders having inside-admission valves 13 ins. diameter, and the low-pressure cylinders having outside-admission valves 15 ins. diameter. These are balanced valves. On top of each steam chest are by-pass valves, for which the steam ports are extended upwards to a horizontal face, and the upper ends of these openings are closed by a flat plate. When the throttle is open, this plate is held upon its seat by the steam pressure. Excessive pressure in the ports will lift the plate from its seat and open communication between the two ends of the cylinder. The Walschaerts valve gear is used. The reversing mechanism is operated by compressed air, under control of a hand lever in the cab. A single reach-rod connects the high-pressure and low-pressure gears; this is placed in the center line of the engine and has a universal joint which is guided between the inner walls of the high-pressure cylinder saddle. As this joint is immediately above the articulated connection of the truck to the main frames, the swing of the truck on curves causes no distortion to the movement of the low-pressure valves. This arrangement is shown in Fig. 5.

The engines with rigid boilers have the boiler supported on the front frames (or truck) by sliding saddles on two cross bearers placed between the axles, and both normally under load. The controlling spring, for bringing the truck and boiler into alinement, is mounted on the forward cross bearer. The bearers are of cast steel fitted with renewable shoes to take up the wear. The sliding saddle support on the truck, the pneumatic reversing gear, and the flexible joints in the steam pipes, are practically identical with the similar parts on engines of the Southern Pacific Ry. (2-8-8-2 class), and were described and illustrated in our issue of April 29, 1909.

On the steam truck, the main frames terminate just beyond the pedestals of the first driving axle, and are bolted and keyed to a steel casting which

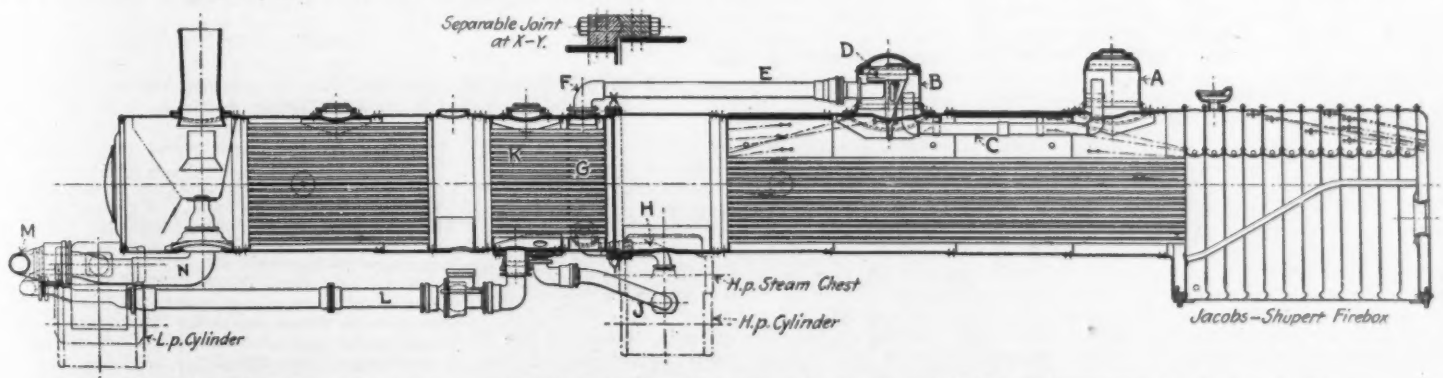


FIG. 4. ARRANGEMENT OF BOILER AND STEAM PIPING (FOR RIGID BOILER) ON MALLET LOCOMOTIVES: A., T. & S. F. RY.

TABLE I.—LARGE MALLET LOCOMOTIVES; ATCHISON, TOPEKA & SANTA FE RY.

Type	2-6-6-2	2-8-8-0	2-10-10-2	4-4-6-2
Wheelbase, rigid	13 ft. 8 ins.	15 ft. 6 ins.	19 ft. 9 ins.	76 ins. & 152 ins.
Wheelbase, total	56 ft. 5 ins.	51 ft. 4 ins.	66 ft. 5 ins.	51 ft. 11 ins.
Weight on drivers, lbs.	317,300	380,000	440,000	268,000
Weight of engine, lbs.	392,300	440,000	500,000	376,000
Cylinders, h. p. (2)	24 × 28 ins.	24 × 32 ins.	28 × 32 ins.	24 × 28 ins.
Cylinders, l. p. (2)	38 × 28 ins.	38 × 32 ins.	38 × 32 ins.	38 × 28 ins.
Steam pressure	220 lbs.	200 lbs.	225 lbs.	200 lbs.
Heating surface; boiler, sq. ft.	3,610	2,930	3,920	3,477
High pres. superheater, sq. ft.	390	580	580	328
Low pres. superheater, sq. ft.	719	1,307	1,307	798
Feedwater heater, sq. ft.	1,893	2,344	2,659	1,279
Length over engine and tender	.....	95 ft. 5 ins.	121 ft. 7 ins.	.....
Tractive force, lbs.	61,500	86,000	110,000	57,000

TABLE II.—DIMENSIONS OF MALLET LOCOMOTIVES OF THE 2-6-6-2 CLASS; ATCHISON, TOPEKA & SANTA FE RY.

Service	Freight
Fuel	Soft coal
Driving wheels (12)	5 ft. 9 ins.
Front truck wheels (2)	1 ft. 7¼ ins.
Rear truck wheels (2)	3 ft. 4 ins.
Tender wheels	2 ft. 10½ ins.
Driving axle journals; main, 10×12 ins.; others	9 × 12 ins.
Wheelbase; driving	37 ft. 10 ins.
Rigid (two groups)	13 ft. 8 ins.
Engine, total	56 ft. 5 ins.
Engine and tender	89 ft. 3 ins.
Weight on driving wheels	317,300 lbs.
On front truck	29,000 lbs.
On rear truck	46,000 lbs.
Engine, total	392,300 lbs.
Tender loaded	169,700 lbs.
Cylinders, h. p. (2)	24 × 28 ins.
Cylinders, l. p. (2)	38 × 28 ins.
Valve gear	Walschaerts
Slide valves	Balanced piston
Diameter; h. p., 13 ins.; l. p.	15 ins.
Boiler, type	Straight top
Diameter of barrel	5 ft. 10 ins.
Thickness of barrel plates	21/32-in., 11/16-in.
Height, rail to center line	8 ft. 11 ins.
Working steam pressure	220 lbs.
Firebox, type	Jacobs-Shupert
Length inside	119⅝ ins.
Width inside	63¼ ins.
Depth	74½ ins.
Thickness, side and crown plates (channels)	5/16-in.
Thickness, tube plate	9/16-in.
Thickness, back plate	⅝-in.
Water spaces; front and back, 5 ins.; sides	5½ ins.
Tubes, iron; No.	294
Thickness, No. 11; diameter	2¼ ins.
Length over tube plates	19 ft. 7 ins.
Feed-water heater tubes; No.	322
Diameter, 2¼ ins.; length	9 ft. 10 ins.
Heating surface; tubes	3,376 sq. ft.
Firebox	200 sq. ft.
Firebrick arch tubes	34 sq. ft.
Feed-water heater tubes	1,893 sq. ft.
Total	5,503 sq. ft.
Superheating surface	390 sq. ft.
Reheating surface (for low-press. exhaust)	719 sq. ft.
Grate area	52½ sq. ft.
Height, rail to top of smokestack	15 ft. 6 ins.
Water in tender	9,000 gals.
Coal in tender	12 tons
Tractive force	61,500 lbs.

supports the low-pressure cylinders. The front pony truck is of the swing-bolster center-bearing type, and is equalized with the front drivers. The rear frames have plate extensions to accommodate the trailing truck, which is of the Rushton pattern, with outside bearings. To reduce flange wear due to curves, oilers are fitted for lubricating the flanges of the front driving wheels, as the engines have to work over curves of 10° (or 16° on sidings).

The articulated connection between the frames is effected by a steel casting (A), which forms a radius bar as shown in Fig. 5. This is bolted to the upper and lower rails (B) and (C) of both forward frames (thus serving as a cross brace), and its rear end is fitted to a pivot or hinge pin (D) about 8 ins. in advance of the center line of the high-pressure cylinders. The upper end of the pin (above the radius bar) is seated in the cylinder saddle at (E), while the lower end is seated in a cast-steel cross brace (F) connecting the main frames. This arrangement permits the two sections of the main frames to move vertically in relation to each other without causing the joint to bind. The rails of each rear frame extend between the rails of the corresponding forward frame (in the same vertical plane), a small vertical clearance being provided. This interlocking of the frames is shown at (G). Any transfer of load between the front and rear frames is effected by contact between the frames.

Mallet Locomotives for Passenger Service.

Mention has been made already of the use by this railway of Mallet engines of special design for handling passenger trains. These engines were built to haul heavy trains on a part of the line having grades of about 1.75% and curves of 16°, and where the average or schedule speed of 25 m.p.h. must be maintained. The dimensions are given in Table I., and one of the engines is shown in Fig. 6. It has the unusual features of an unsymmetrical wheel arrangement (4-4-6-2), and driving wheels of large diameter (73 ins.). The forward portion has a four-wheel leading truck and four driving wheels in the steam truck, while the rear portion has six driving wheels and a two-wheel trailing truck. The leading truck is of the rigid-center type and its spring rigging is not equalized with that of the drivers. It carries a load of about 58,000 lbs. Oil fuel is used, and for steam economy there is the same combination of compounding, superheating and feed-water heating, as in the freight engines described above. A notable feature of these engines (and of some of the freight engines also) is the use of very large tenders in order to maintain a sufficient supply of water in an arid district. The tender carries 12,000 gals. of water and 4,000 gals. of fuel oil, and as its weight in working order is over 100 tons it is mounted on two six-wheel trucks similar to those used under heavy passenger cars.

All the engines were designed under the direction of the Motive Power Department of the Atchison, Topeka & Santa Fe Ry.; Mr. W. F. Buck is Superintendent of Motive Power, Mr. H. W. Jacobs, Assistant Superintendent of Motive Power; and Mr. M. H. Haig, Mechanical Engineer. The engines were built by the Baldwin Locomotive Works.

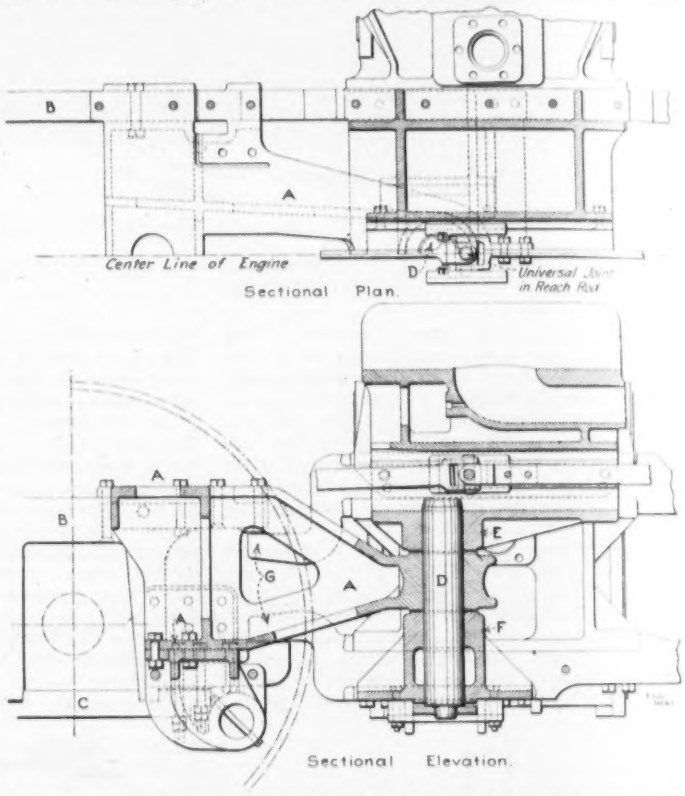


FIG. 5. ARTICULATED CONNECTION OF STEAM TRUCK TO MAIN FRAMES ON MALLET LOCOMOTIVES; A., T. & S. F. RY.

RECORD MONTHLY EXCAVATION AT PANAMA.—The total excavation in the Central Division for the month of March 1911, amounted to 2,032,523 cu. yds., of which 2,012,469 cu. yds. were excavated from the Canal prism, 13,619 from the Obispo diversion and 6,435 from other outside work.

From the Culebra section of the Central Division (Culebra Cut) 1,729,588 cu. yds. were excavated and from the Chagres section, 302,935 cu. yds.

The total excavation from the Canal prism (2,012,469) is the largest ever made in any one month in the Central Division since the commencement of work by the United States, the largest previous records having been 1,996,294 in March, 1909, and 1,987,714 in March, 1910. The total excavation in the Culebra section (1,729,588 cu. yds.) was also the largest ever made in a single month, the highest previous records having been 1,434,597 in March, 1909, and 1,509,728 cu. yds. in March, 1910.

The excavation of March, 1911, is undoubtedly the highest excavation in the prism that will ever be made within the limits of the Central Division for the reason that, owing to the completion of steam shovel work in the Chagres section within the next two or three weeks, except for two small remaining pieces which will be taken out in the next dry season, ten shovels which worked in the month just passed, will be out of commission so far as future work in the Central Division is concerned.—"Canal Record."

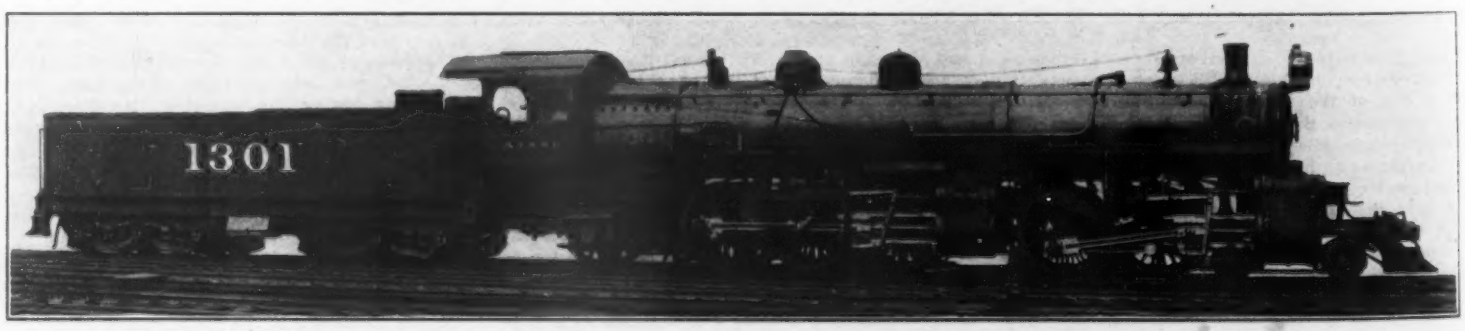


FIG. 6. MALLET ARTICULATED LOCOMOTIVE FOR PASSENGER TRAFFIC (4-4-6-2); ATCHISON, TOPEKA & SANTA FE RY.
(Baldwin Locomotive Works, Philadelphia, Pa.; Builders. The tender weighs over 100 tons and is mounted on six-wheel trucks.)

The Micrometer Alidade and Its Uses.

By R. H. SARGENT.*

The micrometer, as an instrument for making measurements of quantities too small to be measured by direct comparison, has been used for many years on instruments of precision; but so far as can be ascertained, it was not until the early seventies that it was applied to alidades for the measurement of distances in the place of the stadia. The first application of the micrometer for this purpose was made by the United States Coast & Geodetic Survey. It is not recorded that any special enthusiasm was aroused by the instruments which were equipped with the micrometer eye-piece, until about 1899, when they were adopted by the United States Geological Survey for topographical work in Alaska under Mr. W. J. Peters, now in command of the Carnegie Institution's magnetic yacht "Carnegie." Their efficiency has since been proved by extended use. Since 1901, each man who has done work in Alaska, has at first scorned its use, only to be completely won by its efficiency and adaptability for both detailed and reconnaissance surveys.

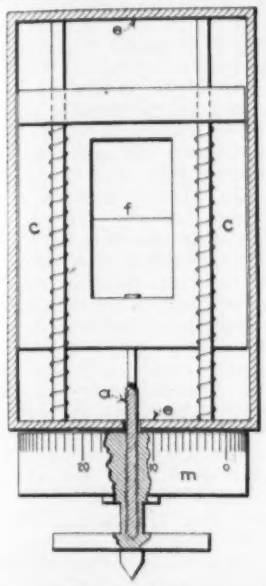


Fig. 1. Cross-Section of Micrometer Attachment, Showing Movable Cross-Hair, for Use With Transits or Plane-Table Alidades.

The principle applied in this use of the micrometer, like that of the stadia, is based upon the fact that if two angles and one side of a triangle are known, the remaining angle and side can be computed. In this instance one side of the triangle used is that formed by a base of known length, established at the point to which the distance is to be determined, and the other sides are the lines of sight from the instrument to the ends of this base. The length of the base is ascertained by previous measurement; it is a chosen space upon a stadia rod, or the distance between two targets of some nature affixed to supports, such as trees or poles placed in the ground. In the foregoing statement, the base is considered at right angles to the line connecting its middle point with the instrument. Therefore the angle between the base and a line connecting either end with the instrument so closely approaches 90° that it may be so considered in this discussion.

The function of the micrometer is the measurement of the angle at the instrument between the lines of sight to both ends of the base. In the stadia instrument, this angle is a constant by the use of fixed stadia hairs, and the variable quantity is the base subtending this angle. By the use of the micrometer, the angle subtending the fixed base is measured by the movement of the cross-hair *f* (Fig. 1), which is attached to a sliding plate *c c*, moved by means of a screw *a*. The head of this screw *m*, which is at the lower end of the micrometer box *e e*, is a disk about three-fourths of an inch in diameter, the circumference of which is graduated into 100 divisions. By revolving this micrometer head the sliding plate is moved, thus causing the hair to pass before the vision. From a series of tests upon given bases at known distances, the angle subtending the amount of movement of the hair by the revolving of this head one division can be computed. After this has been accurately determined, the angle between any lines of sight may be measured. This angle and the length of the base being known, the other sides of the triangle, or the distance between the instrument and the base, may be readily computed. For general use a table of revolutions and different bases is made, from which the required distance may be easily taken.

*Topographer, U. S. Geological Survey, Washington, D. C.

The value of one division of the wheel and the constant for each micrometer may be determined as follows: Place bases at stations 500, 1,000, 1,500 and 2,000 ft. from the center of the instrument, measuring these distances carefully with a tape. The constant is based upon distances measured from the center of the instrument, which eliminates the necessity of applying the correction for the focal length of the telescope lenses. The bases may be constructed by driving small stakes into the ground and measuring with care the distances between the tops. At the 500-ft. station two stakes should be set 5 ft. apart and another between them 3 ft. from one end, thus giving three bases, one of 5 ft., a second of 3 ft. and a third of 2 ft. At the 1,000-ft. station the extreme stakes should be set 8 ft. apart with an intervening one 5 ft. from one end. At the 1,500-ft. station the extreme base should be 10 ft. in length, with sub-bases at 4 ft. and 6 ft., and at the 2,000-ft. station the longest base should be 15 ft., with intervening bases of 7 ft. and 8 ft.

Fig. 2.

Adjust the hair by means of the micrometer head until it covers one end of a base, then revolve the head until the other end of the base is covered, noting the number of divisions passed over on the head, the length of base used, and the distance between it and the instrument. At least ten readings on each of the bases should be made and the mean of the results reduced to a hypothetical base of 1 ft. at a distance of 100 ft. For example, if at a 1,000-ft. distance on a base of 6 ft., 365 spaces were turned on the micrometer head, at 100 ft. on a base of the same length theoretically, 3,650 spaces would be turned; but if the base were reduced to 1 ft. at 100 ft., 608.33 spaces would be the result. After having reduced all the readings thus and averaged them, the result is applied in the following formula:

$$(1)\quad d = \frac{B}{H\,R \sin 1''}$$

in which:

R = number of divisions turned by micrometer head,

d = value in seconds of arc of one division of the micrometer head,

H = distance from instrument to base,

B = length of reduced base.

Therefore:

$$d = \frac{1}{100 \times 608.33 \sin 1''}$$

1 log	= .00000
100 colog.	= 8.00000
608.33 colog.	= 7.21586
Colog. sin 1"	= 5.31443
Log. d	= 0.53029

d = 3".391.

C, is the constant or ratio to be found for each instrument,

$$C = \frac{1}{d \sin 1''}$$

Substitute the value of d from the first equation and the formula becomes:

$$C = \frac{H\,R}{B}$$

B = 1 ft. colog.	= .00000
H = 100 ft. log.	= 2.00000
R = 608.33 log.	= 2.78414
Log. C	= 4.78414

Constant = 60833.

By transposition in the last equation we have:

$$H = \frac{B\,C}{R}$$

Example:

Base or B = 6 ft.

Divisions on the head or R = 365.

Find the distance from the base or H.

$$H = \frac{B\,C}{R}$$

$$\therefore H = \frac{6 \times 60833}{365} = 999.999 \text{ ft. or } 1{,}000 \text{ ft.}$$

When the instrument is used for running lines of comparatively short sights, a table similar to the following may be used: (This of course will have to be computed for each instrument.)

Miles.	Divisions. 1	2	3	4	5	6	8	10 Bases
0.21	56	112	168	224	280	336	448	560
0.22	53	107	160	214	268	322	428	535
0.23	51	102	153	204	256	307	409	512
0.24	49	98	147	198	245	294	392	490
0.25	47	94	141	188	235	282	376	471
0.26	45	90	136	181	226	276	362	453
0.27	43	87	131	174	218	261	348	436
0.28	41	84	126	168	210	252	336	420
0.29	40	81	121	162	203	243	324	406
0.30	39	78	118	157	196	235	312	392

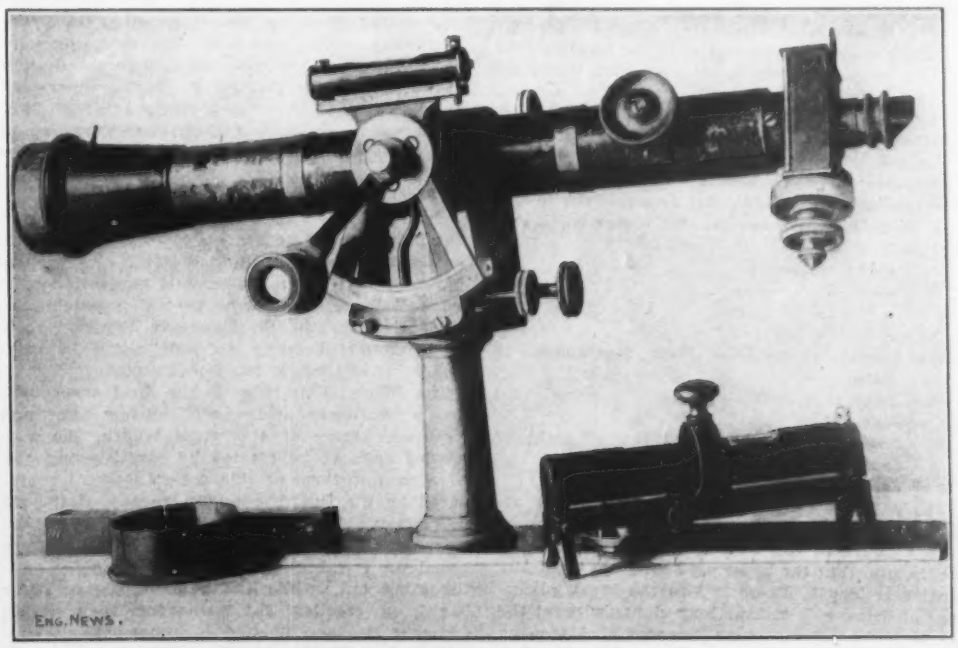


FIG. 3. PLANE-TABLE ALIDADE WITH MICROMETER ATTACHMENT USED BY THE U. S. GEOLOGICAL SURVEY.

The figures 1, 2, 3, etc., shown at the head of the table are the length in feet of bases which are used, either upon a stadia rod or established upon the ground. In the left hand column marked Miles, the quantities 0.21, 0.22, 0.23, etc., are 100ths of a mile. The figures in the body of the table represent the number of divisions read on the micrometer head. In explanation of the use of the table, let us suppose that a base of 5 ft. has been used and 254 divisions have been recorded from the micrometer head. Following down the column headed 5, the nearest figure to 254 is 256. By following this line to the left we find that 0.23 miles is the distance. If a closer determination of the distance is required, it may be found by interpolation. For longer distances and greater bases than might be shown in such a table, the computation is quickly made by applying in the formula $H = \frac{B\,C}{R}$, the constant for the particular instrument.

The bearing of a horizontal base constructed on the ground must be ascertained in order that the angle between it and the line of sight from the instrument may be known and used in the computation of a corrected base. If the work is being executed by means of a plane-table, with the table in orientation, the direction of the base may be drawn on the sheet. If a transit is being used for the work, the bearings of the base and the line of sight may be determined, either directly by means of a compass, or by the angle between them and a line of known direction.

When occupying a point at which it is desired to use this base for ascertaining the distance between it and the point occupied, the correct length of the observed base may be obtained in the following manner. Suppose $a\,b$ in the diagram (Fig. 2) represents the base established, and $a\,d$ and $b\,d$ the lines of sight from the station occupied to the base. Since the angle d' at the instrument between the lines of sight is so very small that if a perpendicular were erected from a to the line connecting the instrument at d with the center of the base, the angle which it would make with $b\,d$ at b' so closely approaches 90° it may be considered as such. Orient the plane-table as closely as possible, either with the magnetic needle or by inspection, then, by placing the alidade upon the point a on the paper, sighting to the signal a on the ground and drawing the line $d\,a$ upon the paper, we have the angle x between the base and the line of sight. Plot upon the paper the line $a\,b$ as long as possible. For instance, if it is 10 ft. on the ground, if possible, plot it 10 ins. on the paper. Then from a erect a perpendicular to $d\,b$. This line $a\,b'$, measured by the same scale as that by which $a\,b$ was plotted, will be the length of the corrected base or B, to be used in the fore-going formula. If a table of sines is available, and also a protractor, the angle y may be measured and the length of $a\,b'$ found by multiplying the sine of y by the length of $a\,b$. The same principle applies to a signal erected vertically, which is above or below the station occupied.

In case a horizontal base above or below the instrument is used, and it is desired to reduce the reading to the horizontal distance, the following formula, which can be easily derived, should be used:

$$H = \frac{(ab)\,C \sin y \cos v}{R}$$

In which:

H = Horizontal distance from instrument to base,
ab = Base as erected,
C = Constant,
y = Angle between base and line of sight of instrument,
v = Vertical angle at instrument.

The superior advantage of the micrometer attachment lies particularly in the fact that much longer distances can be measured than with the stadia, and that the bases used need not be of any particular length. There is also the great advantage of being able to take long sights without the necessity of relying upon a rodman, since the bases used may be constructed and left standing. In many instances in the work of the topographers of the Alaskan Division of the United States Geological Survey, by whom this instrument is much used, bases are constructed not only for immediate use, but at points to which it is known readings will be desired in the future. The lengths and bearings of the bases are recorded when established, although they may not be used for weeks after their construction.

In the traversing of streams or shore lines, where long sights are desirable, and oftentimes necessary, the delay of awaiting the advance of a rodman would be great; here the value of the micrometer can hardly be over-estimated. It has not been an uncommon occurrence to use bases as long as 150 ft. for determining distances as great as twelve miles, and the record books of some of the Alaskan topographers show the use of bases 500 ft. and more in length used at distances of over 25 miles.

Another condition in which the micrometer attachment is of great value is in traversing roads or trails where there is much brush. Suppose, for example, that the distance between the stadia rod and the instrument is 500 ft. In the use of stadia wires it is necessary for the observer to see two points on the rod which are 5 ft. apart, or if he uses half the interval, 2½ ft. His alternatives are chopping brush or estimating a portion of the distance on the rod, the latter being little better than a guess. In any case it is seldom that there cannot be seen two places on the rod, the exact distance between which is known. Since with the micrometer alidade, any base may be used, within the field of vision, this method is particularly applicable under such conditions.

The accuracy obtainable is equal to that by the stadia method. A recent test of two micrometer instruments over a measured distance of 3,100 ft. gave an error of measurement of but 0.1 of 1% by one instrument and 0.5 of 1% by the other.

The type of alidade equiped with the micrometer eye-piece is increasing in favor each year. In the hands of a careful and painstaking observer, it is an instrument capable of accurate and rapid work.

Designs for the New Quebec Bridge, and the Accepted Design.

[With two-page inset sheet.]

As we have already noted, the contract for the reconstruction of the Quebec Bridge has been awarded to the St. Lawrence Bridge Co. of Montreal, a Canadian concern, being a combination of two Canadian bridge companies, the Dominion Bridge Co. of Montreal and the Canadian Bridge Co. of Walkerville, Ont. We are now able to show an outline sketch of the design on which they were awarded the contract, and sketches of the competing designs, reproduced (from an official drawing) on a two-page inset sheet herewith. The following notes based on official information explain the designs.

The bidders for the Quebec Bridge superstructure were: St. Lawrence Bridge Co., of Montreal. Maschinenfabrik Augsburg-Nürnberg A. G., of Gustavsburg, Germany. British Empire Bridge Co., of Montreal. Pennsylvania Steel Co., of Steelton, Pa.

Tenders were based on the plans and specifications prepared by the Board of Engineers, but contractors could, if they desired, also prepare plans of their own and submit tenders thereon. Three of the above firms availed themselves of this privilege; the St. Lawrence Bridge Co., in fact, submitted seven different plans, in addition to tendering on the Board's plans.

The Official Plan, Fig. 1 (see inset sheet) was for a cantilever bridge with anchor arms and cantilever arms of the same length, the suspended span to be erected by cantilevering out. Five modifications of this design were also prepared by the Board, a tender on any of the six propositions being considered a tender on the Board's design. Two of these schemes were based on erecting the suspended span by cantilevering out, while the remaining four were based on erecting the suspended span at an adjacent site and floating it into position.

Maschinenfabrik Augsburg-Nürnberg A. G. tendered on three of the designs of the Board. They also submitted a tender on a design of their own (Fig. 2). The principal features of this design are the large panels, the small number of members in the web system and the length of the suspended span. The material proposed was a chrome-nickel-steel. Built-up rivet members were to be used for tension members throughout.

The British Empire Bridge Co. submitted tenders on the Board's design only. They proposed two schemes of erection in connection with the floating in of the suspended span: one floating the span in on high falsework, the other by floating in a light temporary span to be used as staging upon which the suspended span is erected.

The Pennsylvania Steel Co. submitted tenders on the Board's design and one tender on an eyebar suspension span designed by Mr. Gustav Lindenthal (Fig. 3). This company submitted prices on two schemes of erection of the suspended span. In one scheme the suspended span is floated in on high falsework, while in the other the entire span is lifted directly from the pontoons by a special lifting device designed and patented by this company.

The St. Lawrence Bridge Co. submitted a tender on each of the Board's designs and, in addition, seven tenders on designs of their own. In general elevation and outline the designs submitted by this firm conform to that of the Board's design. Two of these designs are of the single-intersection Warren type (Fig. 4), the remaining five being variations of the single-intersection "K" web-system type (Figs. 5 and 6). The variations in the different tenders were due mainly to variations in the details of the members, as well as the proportion of nickel-steel and carbon steel used in the construction.

The Accepted Design was that approved by the majority of the Board as well as by the additional experts appointed by the Government. In the opinion of the engineers this design contained several features, particularly in respect to erection, that rendered it preferable to the designs prepared by the Board.

The design (Fig. 7) will have the "K" web-system in the cantilever and anchor arms, the suspended span being a modified Pratt. All members in the anchor arm and those immediately over the main pier, as well as the floor system, are carbon steel, the cantilever arms and suspended span being of nickel-steel. The top chords are composed of built-up riveted members extending over one full truss panel or two floor panels.

This design differs from those shown in Figs. 1 to 6 by having an 1,800-ft. channel span, as in the old Quebec Bridge. It is also different in making no provision for highway traffic. The suspended span is 640 ft. long, 110 ft. deep at the center and 70 ft. deep at each end. The cantilever arms are 580 ft. long, 70 ft. deep at the end and 310 ft. high over the main post. The anchor arms are 515 ft. long, as at present designed. The trusses are 88 ft. apart and there is a clear headroom of 150 ft. above extreme high water.

The bridge will be designed to accommodate two railway tracks and sidewalks for foot passengers, the Government having decided that no accommodation for highway traffic is necessary. The train load allowed for on each track will be equivalent to two E-60 engines followed by a train load of 5,000 lbs. per lineal foot of track.

The increase in length of span was brought about by a rearrangement in the manner of sinking the caissons, thus allowing the center line of the new bridge to remain coincident with that of the old bridge. The old main piers will not be used, but will be taken down to low water level, the stone being reused in the new piers.

A VERY LONG CONCRETE RAILWAY BRIDGE is to be built by the Philadelphia & Reading Ry. across the Delaware River at Yardley, Pa., to replace a 37-year old wrought-iron truss there. It will be 1,256 ft. long and consist of 14 arches, 12 of which will be 80 ft. 9 ins. span and two 83 ft. 6 ins. The crown of the highest arch will be about 65 ft. above water level. The contract has been let to the F. M. Talbot Co., of New York.

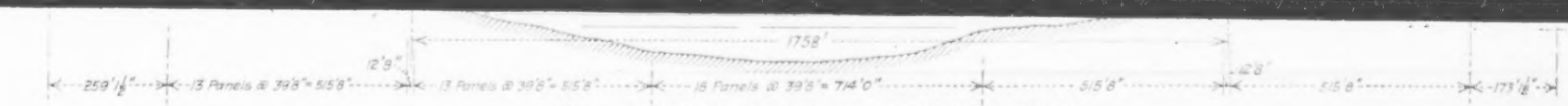


FIG. 4. DESIGN M-N OF THE ST. LAWRENCE BRIDGE CO.

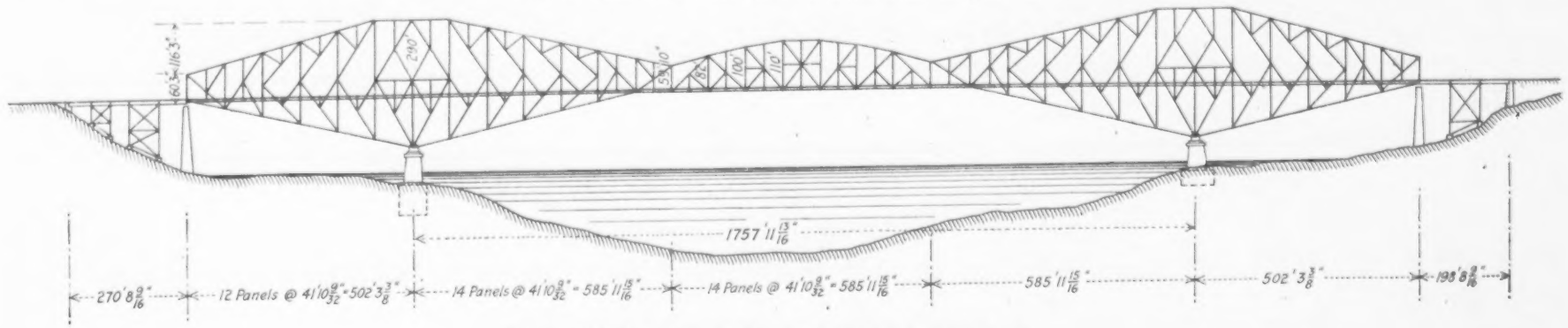


FIG. 5. DESIGN A-B-X OF THE ST. LAWRENCE BRIDGE CO.

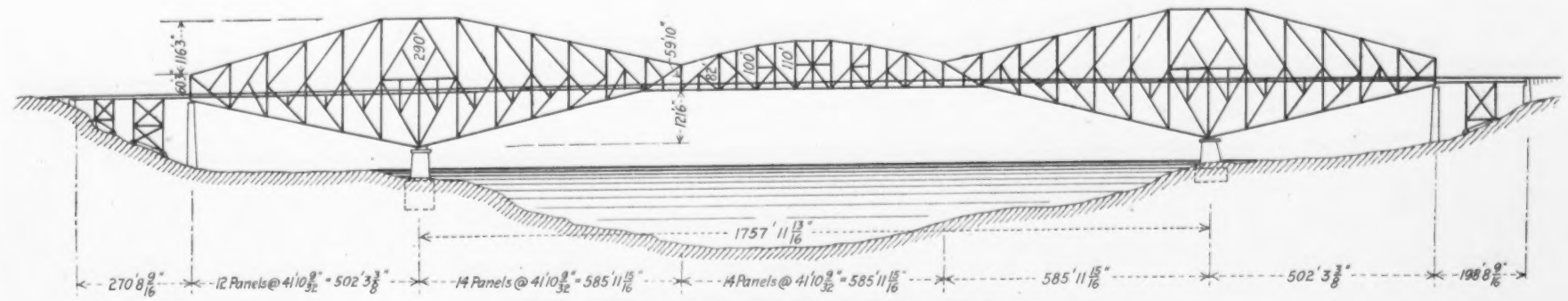


FIG. 6. DESIGN C-Y OF THE ST. LAWRENCE BRIDGE CO.

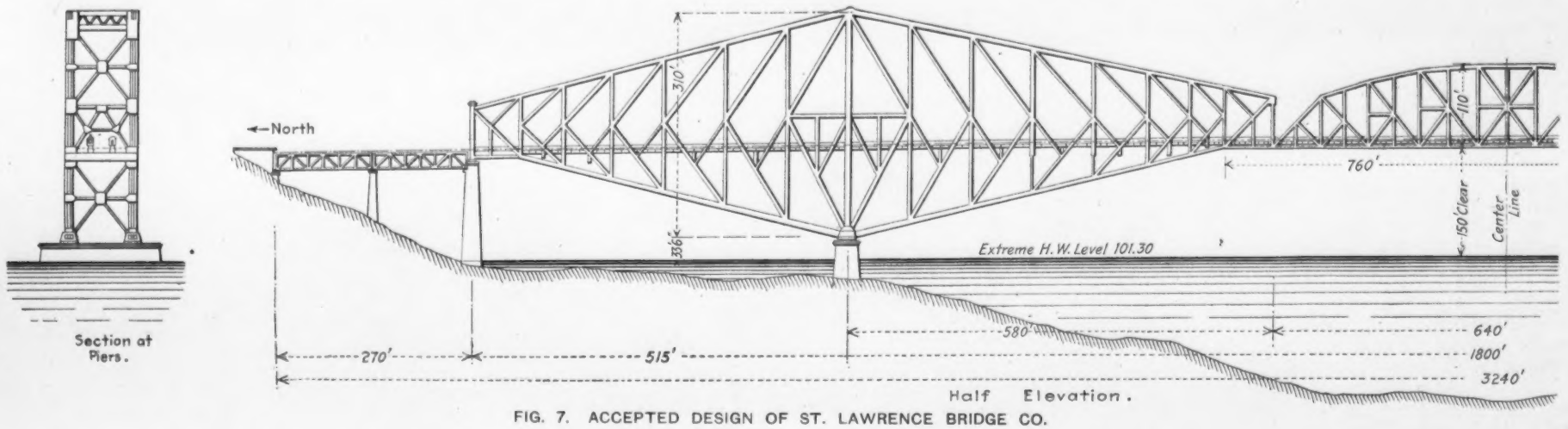


FIG. 7. ACCEPTED DESIGN OF ST. LAWRENCE BRIDGE CO.

OUTLINE DIAGRAMS OF ACCEPTED DESIGN AND SIX COMPETING DESIGNS FOR THE NEW QUEBEC BRIDGE OVER THE ST. LAWRENCE RIVER, NEAR QUEBEC, CANADA.

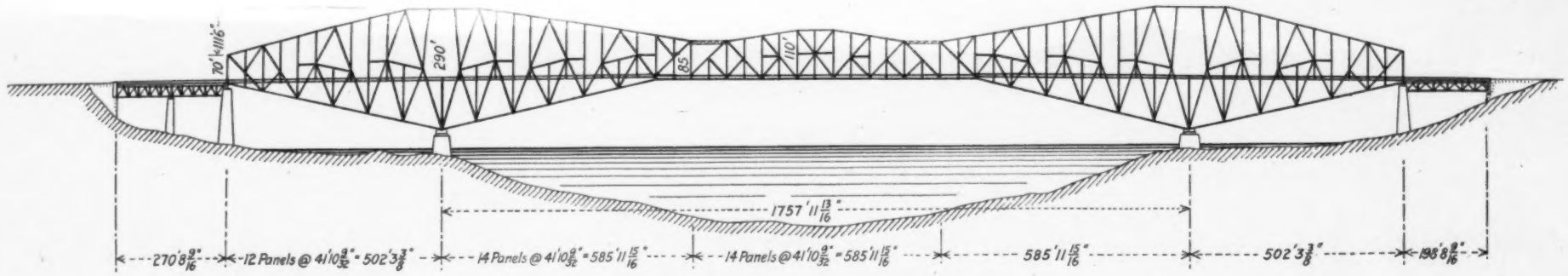


FIG. 1. OFFICIAL DESIGN V, BOARD OF ENGINEERS.

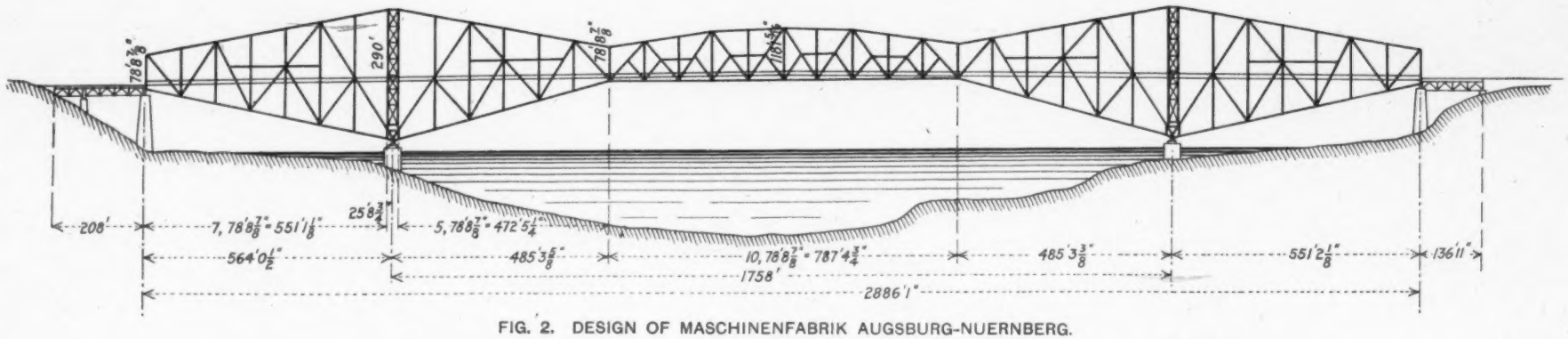


FIG. 2. DESIGN OF MASCHINENFABRIK AUGSBURG-NUERNBERG.

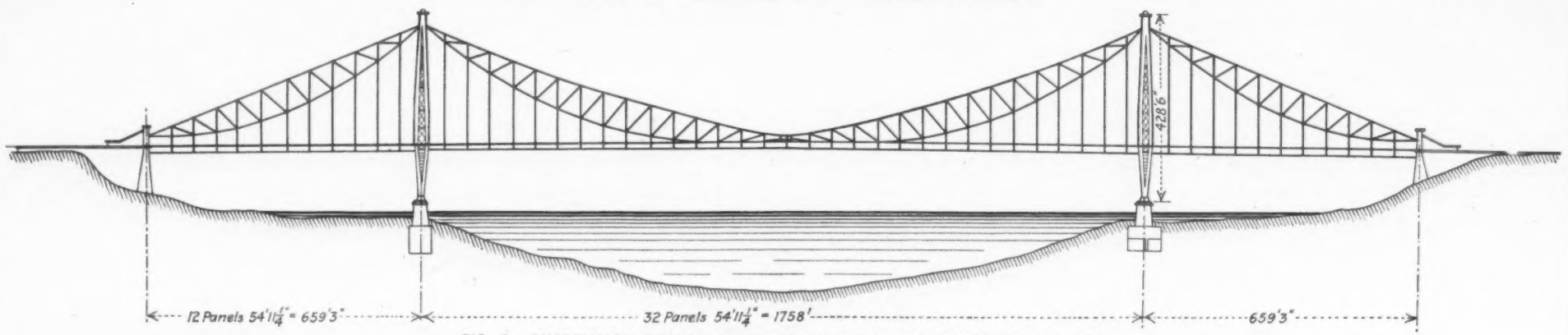
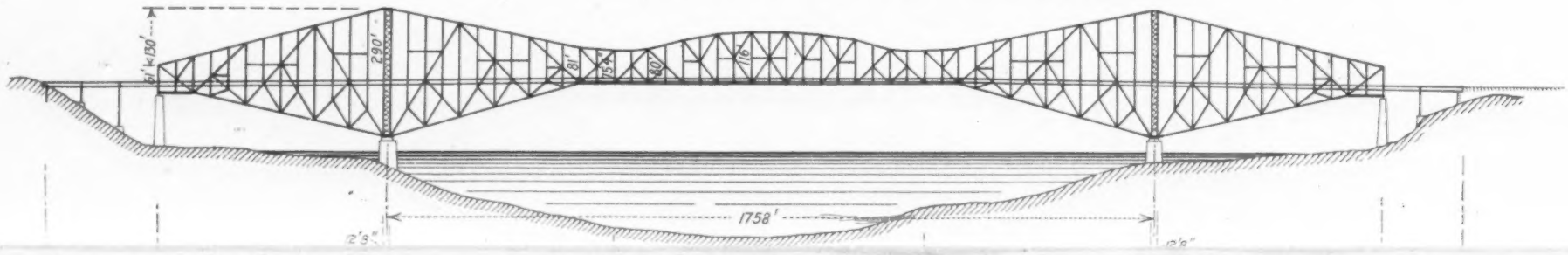


FIG. 3. SUSPENSION DESIGN (LINDENTHAL) OF PENNSYLVANIA STEEL CO.



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The Massachusetts legislature is wrestling with the question whether laws should be enacted compelling the steam railways entering Boston to electrify their terminal lines. A report on this subject by the "Joint Board on Metropolitan Improvements" was printed in our issue of Feb. 2. The majority of that Board (nine members) advised against any compulsory legislation, but a minority report of five favored "some legislative requirement with respect to electrification," while two other members favored further study by some State Board, but believed that legislation at the present time is unwarranted.

There is doubtless a strong public sentiment in favor of compulsory legislation. It is always easy to arouse sentiment in favor of compelling someone else to spend money. People in general do not understand that whatever money a railway spends it must in the long run get back again from shippers and travelers if it is to remain solvent and continue in business.

The principal spokesman for compulsory legislation at the Committee hearings was Mr. Geo. G. Crocker, one of the minority members of the Joint Board above referred to. Mr. Crocker's main argument was based on his belief that the change from steam to electricity would in the end be profitable to the railways. He attempted to show that the chances for electrification proving profitable were better in Boston than in New York instead of worse, as the majority of the Board concluded; but his proof, when analyzed, is found to rest on vague generalities and general assumptions.

He brings forward, for example, the old argument that electrification should be credited with the increase in volume of traffic which will follow its introduction.

It is true that traffic has increased heavily on some roads after electrification; but it has also increased in nearly or quite as great a degree on other roads which have continued to operate by steam locomotives. No doubt there are advantages in the way of frequent multiple-unit train service which electric traction renders possible and which tend to stimulate travel; but the figures for increase of traffic used by the promoters of electric traction should be rigidly scrutinized before acceptance.

It is not, however, worth while to critically analyze the arguments for compulsory electrification. Attention should be devoted instead to the main issue. The proposition for compulsory electrification is that the State should use its authority to compel the railway corporations concerned to adopt a revolutionary system of operation, requiring an investment on some of the roads greater than their entire present capitalization.

The railway companies principally concerned (the Boston & Albany and the New York, New Haven & Hartford) protested before the legislative committee that the burden of electrification should not be placed upon them. Their own investigations of the cost of electrification and of its various claimed advantages have shown results most unfavorable to the change, and they entered strong protest against the proposed legislation.

Mr. Crocker said in substance to the legislators that the change ought to be ordered, nevertheless, because it will in the end prove profitable to the railways.

It would be highly dangerous, however, to order any such revolutionary change, involving such enormous outlays, merely on speculative expectations of what is likely to happen. Actual experience with electrification at New York has not yet been encouraging to the promoters of electricity. To invest some $60,000 per mile, or a total of $22,000,000 in an improvement which shows up to date an increase instead of a decrease in operating expenses, without including interest on the investment, is not a promising record on which to base legislation compelling electrification elsewhere.

But the question at issue is even broader than the question of compulsory electrification.

Engineering News for more than a quarter century has stood for state and federal control of the corporations which conduct public utilities. But while we have held to this ground, we have also freely recognized the danger that the authority of the State may be abused and that an unwise extension of this authority may work serious public injury.

We believe that public control of railways is a necessity; but such control should be exercised with great wisdom and restraint, and particularly when the question involved is compelling corporations to make changes involving heavy investments which may or may not prove profitable. In questions of this sort, the judgment of the responsible officers of the corporation ought to be accepted, and only overruled where the clearest possible case can be made out for the protection of the public interests without infringing the rights of the corporation stock holders.

The disaster at the Pancoast colliery near Scranton, Pa., April 7, presents a most striking instance of the need for refuge chambers in coal mines. It is safe to say that had there been a suitably arranged refuge chamber in this mine on the level where the fire started, not one of the 73 miners whose escape was cut off by the flames would have perished. Only three of these men were found near the scene of the fire. The others were able to retreat to the furthest part of the workings, but having done so they could only wait there until reached by the suffocating gases from the fire. Their bodies were recovered within less than 36 hours, thanks to the early arrival of rescue cars with their trained crews and equipment of oxygen helmets, which only emphasizes the fact that they could have been taken out alive had the mine been provided with refuge chambers.

A system of refuge chambers for an ordinary mine and their construction and equipment in detail has been described by Mr. George S. Rice, M. Am. Inst. M. E., in a paper published in Engineering News, Sept. 22, 1910. Briefly, the chamber would consist of a room about 18 × 75 ft., tunneled out like any other room in the mine, but with extra thick walls and with three tightly fitting doors at each entrance. It was proposed to utilize the prospecting drill holes, suitably cased, for an air supply. Mr. Rice estimated the cost of such chambers completely equipped at $500 each, or the cost of six chambers—enough for most mines—at about $5,000, including connections with the surface.

The mine management, according to press reports of the Pancoast disaster, has agreed to add more than this amount to a "colliery keg fund" started by the miners, from which $100 is to be paid to the family of each adult victim. It appears, then, that in this one accident a complete equipment of refuge chambers would have saved its own cost even from a purely commercial standpoint and leaving out of all account the mental and moral effect on the miners of the heavy loss of life.

In the current discussion respecting pending legislation requiring engineers to submit to examination and license before practising their profession, much stress has been laid upon the benefit the public receives from the compulsory examination and licensing of medical practitioners. It is interesting to note, therefore, in one of the leading medical journals (the "Medical Record" of March 8, 1911) the frank admission that there is considerable humbug in the medical license system as actually carried out. We quote as follows from the article referred to:

> There has been during recent years an uneasy suspicion, amounting in some cases to a conviction, that medical practitioners are sometimes licensed in this country who are not competent to fulfill their duties to the benefit of the community or to the satisfaction of themselves. In the "Old Dominion Journal of Medicine and Surgery," February, 1911, Richard C. Cabot, of Boston, deals anew with the subject. He says there is but one thing to do, namely, to make practical and consequently more searching our existing state examinations for the right to practice medicine.
>
> The majority of such examinations are at the present time entirely in writing, and although most states insist upon proof of a fairly good preliminary and medical education, it is still possible in some states, according to Cabot, for a man to become qualified who has never seen a sick patient, never attended a woman in labor, never dressed a wound, and never written a prescription in his life.
>
> As the author points out, a training of this description is wholly inadequate, nor is it fair to the general public to allow an individual so imperfectly equipped for the practice of his profession to treat patients and prescribe drugs. In order, therefore, to test a person's medical knowledge properly, practical examinations are needed, and in order to be able to pass such examinations a practical training will be essential.
>
> It is no preposterous demand to insist that before a medical student becomes qualified he should be compelled to give evidence of his ability to treat ordinary diseases and injuries. Indeed, such a demand is inspired by sound common sense and tests of this nature are compulsory in great Britain and in other European countries.

It should not be understood that we make the above quotation with the idea that the medical license system should be abolished. Imperfect though it is, it nevertheless affords some protection to the public against the quack. It is certainly suggestive, however, as to the impotence of an examination system, as actually carried out through the instrumentalities created by state legislation, to really do what it pretends to do. If the examination and license system falls so far short in a profession like medicine, where book knowledge is the first and foremost requirement, by how much more would it fall short in the engineering profession, where sound common sense and practical wisdom born of experience and good judgment, are always more important than the information which has been gained by study in the schools?

In an interesting discussion on water-tank hoops at the convention of the American Railway Bridge and Building Association last October, the classic question of wrought-iron versus steel was brought out into the arena. A summary of the results ought to be worth the attention of those few but earnest students, like Prof. H. M. Howe and Mr. F. N. Speller, who, after

careful search, are unable to find any evidence that wrought iron rusts more slowly than steel. In the discussion (as reported in the Proceedings of the convention, just published) thirteen members expressed opinions, and nine of these went on record as favoring the exclusive use of wrought iron for tank hoops, while the other four did not commit themselves on either side. Looking for experience rather than opinion, we find that seven out of the nine wrought-iron advocates based their views on more or less definite experience. Extracts will show the nature of this experience:

(1) Last summer we took down another tank that had been up 18 years, and found the flat, wrought-iron hoops in perfect condition, and I took those hoops and put them in a tank that had been up for 12 years where the steel hoops were failing off.

(2) I am greatly in favor of wrought-iron hoops. I can cite cases of tanks that have been up 35 years and never had a hoop changed. * * I have known of steel hoops breaking after only three to five years' service.

(3) Our standard hoops are of Lowmoor iron, and we have some that have been on for 25 years. * * There was one tank * * afted it had been up for five years, one of the men sent in a piece of one of the hoops which had fallen off. * * (Later) the tank burst. They were steel hoops, when they were supposed to have been Lowmoor iron.

(4) * * the Baltimore & Ohio R. R. has adopted a wrought-iron hoop and we do not order anything else. * * With steel hoops it is necessary to renew them every ten or twelve years.

(5) We use flat hoops, and * * where we have used wrought-iron we have never had a failure. * * Five years ago we put up a tank with flat steel hoops, and I think it was just about 1½ years when the tank broke.

(6) We have other tanks with wrought-iron hoops which are 26 to 28 years old.

(7) I have one still standing that is 39 years old. It has the original hoops on it, and it would be pretty hard to talk anything into my head but the old-fashioned wrought-iron flat hoops. I put in two sets of steel hoops before I learned what they were. After that I quit using them. Nevertheless one set of them is still in use; the other was taken off after ten years.

We believe it was Prof. Howe that settled the attempts to explain the superior resistance of wrought iron as against steel by saying that there was nothing to explain. He accounted for all recorded observations by showing errors of observation, faulty drawing of conclusions, prejudice, etc. But among the seven cases cited above, is it likely that *all* the conclusions are in error? If not, Prof. Howe need not feel that he is wasting time in finding the reason for the difference of behavior of the two materials, even though the question may be primarily a scientific one at the present time.

The discussion from which we quoted is noteworthy also because it involved the question of round or flat hoops for wooden water tanks. We had thought the prevailing view favored the round hoop as being proof against destruction by concealed rusting of the inner face. But the members who discussed this point were divided in their views, and if anything the majority preferred the flat hoop. No direct testimony against round hoops was given, though the water pocket formed at the upper side and the tendency to crush into the wood from insufficient bearing were used as arguments by those who spoke for flat hoops. The discussion is of value in suggesting that the flat hoop is not as black as it is painted.

We again remind our readers that engineers making any important change of position are requested to forward a statement of the change for notice in our "Personal" Column.

We desire to have this column cover as wide a range as possible, and to report events of real interest concerning men in all branches of the profession.

In order to keep the department within reasonable limits of space it is necessary to make certain rules as to classes of items to be included and those which should be excluded. Under the latter head come the ordinary engagements of consulting engineers, notices of reelection and reappointment and announcements of the delivery of addresses by engineers before societies, or colleges. It will be manifest on a little thought that if it were attempted to include items of these classes in the "Personal" department and make the record anything like complete, the space devoted to it would have to be greatly enlarged and, besides that, the matter presented would have a very limited interest.

It may be well to impress here, too, upon engineers the duty of forwarding to us a prompt notice, with suitable material for a brief biography, whenever the death occurs of some personal friend, well known in the profession. Engineering News covers so wide a field geographically that it must rely upon its subscribers for the information from which to prepare appropriate notices with reference to engineers who have passed away.

The Present Development and Future Possibilities of the Mallet Type of Locomotive.

One of the notable features of the development of modern motive-power equipment in this country is the extensive adoption of the Mallet duplex articulated locomotive. This development has been attended also by a continual increase in the size and power of these engines, several of which have successively held the record as "the largest locomotive in the world." Particular attention is drawn to this type of engine at the present time by the decision of the Atchison, Topeka & Santa Fe Ry. (one of its most extensive users) to employ Mallet engines exclusively in operating standard 2,200-ton fast-freight trains over its entire main line between Chicago and San Francisco. This includes, of course, both prairie country and mountainous country, and the engines will be of size and power varying with the conditions of the several operating divisions.

This type of locomotive was invented some 23 years ago by Mr. Anatole Mallet (of Paris, France), who was also the inventor of the first practicable and commercially successful compound locomotive. The purpose and principle of the design was to effect a combination of high power, light axle loads and short rigid wheelbase, so that engines of high tractive power could be operated on lines of light construction and of unfavorable conditions as to grade and curvature. The features of the design consisted in (1) the distribution of the load upon several axles and (2) the division of the axles into two separate groups, each having its own cylinders, and the forward group being carried in a swiveling truck frame. The compound system was adopted, with the high-pressure cylinders for the rear group and the low-pressure cylinders for the truck. The distinction between the Mallet type and the Fairlie (and Fairlie-Meyer) type is that the latter arranges both groups of axles in swiveling trucks. The Mallet engine, with the rear group carried in ordinary rigid frames, reduces the complications of steam pipes and flexible pipe joints, while it gives equal facility for operating on curves.

The first of Mr. Mallet's articulated locomotives was exhibited at the Paris Exhibition of 1889, in connection with a system of portable railway track construction. It was a tank engine of only 11½ tons in weight, of 0-4-4-0 class, and operating on a track of 2 ft. gage. In 1891, the Gothard Railway, of Switzerland, had a Mallet 95-ton tank engine of the 0-6-6-0 class, and in 1902 about 500 engines of the Mallet type were said to be in use. The earliest engines were described in Engineering News of June 1, 1889, and Aug. 15, 1891, and a number of the more modern engines have been illustrated or described in our columns. Some recent developments also are noted elsewhere in this issue, while an article in our issue of Jan. 5, discussed the use of Mallet and other adhesion locomotives for operating steep-grade railways.

The first Mallet locomotive in this country was the 125-ton engine exhibited at the St. Louis Exhibition in 1904. This was of the 0-6-6-0 class, and was built for pusher service on the Baltimore & Ohio Ry. Since that time the use of this type of engine has increased rapidly, and over 400 locomotives have been built (including those converted from the ordinary to the Mallet type). The size and power have increased also, reaching a maximum (for the present) in an engine of the 2-10-10-2 class, weighing 250 tons without tender. This would be exceeded materially by a triple-expansion engine projected recently by Mr. S. M. Vauclain, having two groups of wheels and two steam trucks. The Mallet engines are used almost exclusively in freight service, although a very few have been employed for operating heavy passenger trains over severe grades. It may be noted, however, that the development in this country has not been entirely in engines of large size. On the contrary several engines of 70 to 100 tons weight have been built for service on logging railways.

Referring to the Mallet engines as most generally used for heavy freight traffic on main lines, it is evident that the great majority are employed either as pusher engines for helping trains over individual grades, or as road engines for handling heavy freight trains over divisions handicapped by specially adverse operating conditions in the way of grades and curves. To a smaller extent they have been used for handling trains of enormous size and weight on lines of more favorable operating conditions, but with such heavy traffic as to cause congestion and continual trouble. In many cases the introduction of the Mallet engine has practically revolutionized the freight-train service, the number of trains being reduced materially by consolidating them into fewer trains of greater length. In this way, while the train tonnage is increased, the train mileage and engine mileage are decreased, and the work can be done by a smaller number of engines. Further, a considerable increase in traffic can be handled without increasing the train service or equipment. Fuel and engine repair costs may be reduced, and the labor cost reduced also, even allowing for the fact that enginemen now receive higher pay when handling the large Mallet locomotives.

So apparent are the advantages of operating traffic in this way that some railways have undertaken to convert existing engines of the ordinary type to the Mallet type. In a few cases this has been done by combining two of the older engines to make one Mallet engine, with suitable alterations to the cylinders, piping, etc. This plan, however, if carried out extensively, would have the effect of reducing the number of engines disproportionately. The better and more usual way is to build a new separate unit (embodying the steam truck and the forward portion of the boiler), and to combine this with one of the older engines to form a Mallet duplex engine.

An important development in the economy of the locomotive, incidental to the use of the Mallet type of engine, is the introduction of appliances which tend to make the engine a more efficient machine by enabling it to utilize a greater portion of the heat generated. There is a great length available for the boiler, but, on the other hand, the maximum economic length of boiler tubes (and, consequently, the length of the steam-generating portion of the boiler) is about 20 ft. The additional length available can be utilized to advantage for the provision of devices for superheating the steam and heating the feed-water by the waste gases, after the maximum absorption of their heat has been effected by boiler tubes of the greatest economic length. An English engineer, some time ago, wrote sarcastically as to the various auxiliary appliances installed on the long-boiler Mallet engines of American railways. But he evidently missed the point entirely. The total length of the engine is necessarily great, and the steam truck needs a certain weight for adhesion. Any addition to the tubular generating portion beyond a length of 20 ft. would be of little value, and instead of loading the truck with mere dead weight for adhesion it is better economy to use an extension shell of the boiler for devices which will develop a very real and practical economy by absorbing additional heat from the products of combustion, which heat would otherwise go to waste.

The prime or fundamental reason for the prompt and extensive adoption of the Mallet locomotive in this country is the constant endeavor of the railways to effect economy in operating expenses by reducing the cost of freight transportation. This economy may be realized to a large extent by increasing the train tonnage,

and hauling the maximum train loads over the entire length of the line. This requires very powerful motive-power equipment, and the Mallet engine offers a combination of high power with reasonable axle loads and great flexibility of wheelbase. These latter features are of importance in avoiding exceptional loading or stressing of the rails and bridges, and in enabling the engine to work readily over lines with numerous and sharp curves and a relatively light track.

With engines of the ordinary type, the practical limit is five driving axles, and the use of so large a number is quite exceptional. With the Mallet type, however, eight or ten driving axles can be used. Probably the largest and most powerful engines of the ordinary type are the 2-10-2 tandem-compound locomotives of the Atchison, Topeka & Santa Fe Ry., first brought out in 1904. These had a weight of 143 tons (114 tons on the drivers) and a tractive force of 45,000 lbs. But a Mallet engine of equal or greater power, with six driving wheels (in two groups), will have greater flexibility and may have a lighter load per axle. Further, the Mallet locomotive may have also a smaller ratio of adhesion weight to tractive power.

The economic advantages of the Mallet type have been listed substantially as follows in a recent report by the motive-power department of an important railway:

(A) Traffic Advantages:

1. Reasonable first cost.
2. Maximum efficiency for required service within the given limits of track construction, weight and clearance.
3. Maximum paying tonnage per train.
4. Minimum number of locomotives and crews for handling a given tonnage.
5. Maximum hauling capacity per crew.
6. Maximum tractive force in a single unit.
7. Maximum retarding effect for the safe handling of heavy trains in descending steep grades.
8. Ability to move half the train in the event of one set of machinery being disabled.
9. Low train mileage and engine mileage with high train tonnage.

(B) Mechanical Advantages:

1. Distribution of weight over a maximum number of driving axles.
2. Minimum journal load and wheel load, with consequent relief on track and bridges.
3. Maximum effective wheelbase and short rigid wheelbase.
4. Flexibility on curves, with consequent minimum wear of rails and wheel flanges.
5. General advantages of the compound system, superheating, etc., in effecting a high degree of fuel economy.
6. Subdivision of machinery.
7. Minimum weight of engine working parts and consequent minimum cost of engine repairs.
8. Minimum cost of boiler repairs in relation to cost of engine repairs, due to the use of one boiler for two sets of machinery.
9. Ease and simplicity of operation.

Hitherto the use of the Mallet engine has been rather as an auxiliary to the ordinary equipment, where conditions are not favorable to the latter. An important development is in view, however, in the adoption of the Mallet engine as the standard type of road engine for handling freight service, the standard weight of train being increased materially. We have referred already to the notable program of the Atchison, Topeka & Santa Fe Ry. in providing for the use of freight engines of the Mallet type for the entire main line between Chicago and the Pacific coast. A thorough study of the subject convinced the officials that there are great possibilities of economy in the general use of these engines. The plan provides for the hauling of fast-freight trains of 2,200 tons over the entire length of the line, the size and power of the engines on the different divisions varying, of course, according to the operating conditions.

To provide the necessary equipment, it is proposed to use four existing types of engines for conversion to the Mallet type. These four types with their cost (when new) are shown in Table I; the table shows also the cost of a new front unit for each class, including the cost of uniting the old and new portions to form one complete engine. In Table II is given a comparison of the respective number of ordinary and Mallet engines required to handle a given tonnage on seven consecutive divisions (aggregating 880 miles). Pushers would still be required at certain exceptionally severe grades.

TABLE I.—COST OF CONVERTED MALLET LOCOMOTIVES.

Original engine.		Cost of new unit.	Total cost of Mallet engine.
Type.	Cost.		
2-6-0	$14,500	$10,000	$24,500
2-6-2	18,000	12,000	30,000
2-8-0	21,000	13,000	34,000
2-10-2	24,000	15,000	39,000

TABLE II.—NUMBER AND TYPE OF ORDINARY AND MALLET LOCOMOTIVES FOR HANDLING PRESENT TRAFFIC.

1,000 loco-miles per month.		Ave. train load, tons.		Locomotives required.			
				Ordinary.		Mallet.	
Ordinary.	Mallet.	Ordinary.	Mallet.	No.	Type.	No.	Type.
45	26	1,134	2,000	17	2-8-0	11	2-8-8-0
29	20	1,550	2,200	12	2-8-0	9	2-6-6-2
50	27	1,044	1,945	26	2-10-2	15	2-10-10-2
49	27	1,075	1,938	19	2-10-2	11	2-10-10-2
50	27	1,225	2,215	20	2-10-2	12	2-10-10-2
20	13	1,400	2,100	13	2-10-2	10	2-10-10-2

With the gross ton mileage remaining constant, the locomotive mileage will vary inversely as the tonnage rating. It is estimated that with the Mallet locomotives the cost of engine repairs can be reduced 14 per cent., and of fuel 30 per cent., on a ton-mile basis. Wages of enginemen and trainmen will be less (with the smaller number of trains and crews); but as enginemen are allowed higher pay for handling the Mallet engines, an increase of 10 per cent. in their pay is assumed in the estimate.

There will be some expenses incidental to the use of these engines; for instance, it is estimated that it will cost $10,000 to replace each turntable with one of 120 ft. diameter, and $1,500 to lengthen a roundhouse stall to accommodate the longer engines. In Table III is given a summarized estimate for the operation of one division of the railway for a year, including the initial cost for engines, etc. The program for the rearrangement of power equipment and the operation of the entire system of the railway by Mallet locomotives calls for a total expenditure of about $5,000,000, being $4,500,000 for 300 locomotives and $500,000 for turntables and roundhouse stalls. The calculated annual saving in cost of operation, due to the adoption of the heavier and more efficient power equipment, is $2,500,000, or 50 per cent. on the expenditure. In this general estimate no credit allowance is made for the locomotives released from service.

There are some additional minor economies due to the new system of operating. These include the following: (1) engine lubricants, small supplies and water; (2) roundhouse expenses; (3) train supplies; (4) injuries to persons and damages to property and stock. The saving in items (3) and (4) is in direct relation to the number of trains, and will decrease as this number is decreased. The gross amounts of these four items are comparatively small, and they have not been taken into account in the general estimate.

The actual results obtained from the Mallet engines now in service on the road in question are said to fully support the estimates of economy due to the general use of engines of this type. A close comparison in fuel economy is afforded by certain pusher service in California, where each train has two pusher engines, one being of the 2-8-0 class and the other a 2-8-8-2 Mallet engine. These two engines, working in exactly the same service, show a respective fuel consumption of 581 lbs. and 405 lbs. per 1,000 ton-miles; this is a saving of 176 lbs. (or 30.3%) for the Mallet engines.

In boiler efficiency, the Mallet engine shows a marked superiority, as might be expected from the large amount of heat-absorbing surface afforded by the feed-water heater, the superheater, and the reheater for the low-pressure exhaust. On the Atchison System, a Mallet engine of the 2-8-8-2 class showed an absorption of 81.4 per cent. of the heat in the fuel by the boiler and these three auxiliaries, while the smokestack temperature of the waste gases was only 405° F. On the other hand, a tandem-compound 2-10-2 engine (without superheater) showed a boiler efficiency of 74.6 per cent. and a smokestack temperature of 584° F. Further, a simple 2-8-0 engine, with smokebox superheater, showed 70 per cent. and 576° F. respectively. All of these figures are the average of several service runs, those for the Mallet engine being for five runs at maximum capacity on a 2.2% grade for 50 miles at 11 m.p.h. Very similar results have been obtained on the Southern Pacific Ry.; in this case, the Mallet engine had no superheater, but only a feed-water heater and a reheater for the low-pressure exhaust. The boiler efficiency was 78.52 per cent., and the smokebox temperature 451°; on a 100-ton simple engine of the 2-8-0 class in similar service, the figures were 72.83 per cent. and 738°, respectively.

It has been assumed in some cases that an inherent objection to the Mallet type of locomotive is an excessive internal resistance; in other words, that it consumes an excessive proportion of its power in propelling itself upon the track. This claim does not appear to be sustained by experience or experiment. In drifting tests with a Mallet engine of the 2-8-8-2 class, runs were made at different initial speeds, and the engine came to constant speed of about 10 m.p.h. on a grade of 0.84 per cent. That is, the internal resistance of the engine at 10 m. p. h. was equivalent to the grade resistance of the above grade, or about 17 lbs. per ton. To determine the resistance at various speeds, the Mallet engine and a 2-8-0 ordinary engine was hauled behind a dynamometer car on level track with results as follows:

		Mallet. 2-8-8-2	Ordinary. 2-8-0
1.	Weight, incl. tender, lbs.	700,000	391,000
2.	Tractive force, lbs.	108,000	44,000
3.	Tractive force to move engine at 10 m. p. h.	7,100	4,000
4.	At 15 m. p. h.	9,750	5,750
5.	At 18 m. p. h.	11,500	6,750
6.	Ratio of (3) to (2), per cent.	6.6	9.1

Traffic is continually increasing, and will continue to increase. But this increase cannot be met by simply multiplying the engine equipment in proportion. On the contrary, the constant aim must be to handle the increased traffic with a minimum additional equipment. In other words, to work the equipment to its greatest possible efficiency. What has been done already in this way is indicated by figures for a group of Southwestern States (Section 8 of the Interstate Commerce Commission classification) for the decade 1897-1907. In this district the freight-ton mileage increased 175 per cent., and the number of freight cars and through-freight locomotives was increased 89 and 84 per cent., respectively. But the ton-mileage per locomotive was raised 49 per cent., the service of each engine being thus increased in order to cope with the growth of traffic. This condition must continue, but there are, of course, limits to the increase in size, weight and power of locomotives of the ordinary type. The Mallet locomotive, however, affords opportunity for marked development beyond these limitations, and its introduction in regular service promises material advantages both in facilitating the movement of heavy traffic and in increasing the economy of freight transportation.

TABLE III.—COMPARISON OF OPERATION OF FREIGHT TRAFFIC BY ORDINARY LOCOMOTIVES AND MALLET LOCOMOTIVES.

	Locomotives	
	Ordinary.	Mallet.
No. of locomotives	41	24
Tonnage rating	1,385	2,200
Locomotive miles	1,276,861	804,000
1,000 gross ton-miles	1,230,700	1,230,000
Locomotive repairs	$145,465	$125,000
Locomotive fuel	232,014	162,500
Road enginemen	117,398	81,400
Road trainmen	137,468	86,500
Total	$632,345	$455,400
Annual saving		$176,945
24 Mallet engines (at $12,000 for conversion)		$288,000
2 Turntables, at $10,000		20,000
14 Roundhouse stalls lengthened, at $1,500		21,000
Total expenditure		$329,000
Annual saving on expenditure		53.8%

LETTERS TO THE EDITOR.

Kutter Formula Values for Rock-Cut Channels.

Sir: Some of your readers have probably had some experience as to the proper value of "n" to use in Kutter's formula in determining the mean velocity of water in an open cut in rock. The opinions on the subject vary greatly. For instance, in his hydraulic tables Flynn works out an example to obtain the flow of water in a rock cut by means of Kutter's formula and "n" is shown equal to 0.0225. The Reclamation Service in an annual report on the Truckee-Carson project shows some typical sections of the canal, for unlined cut in rock; the coefficient "n" is equal to 0.025. Some engineers with whom I have discussed that question claim that from personal experiments "n" equal 0.035 should be the coefficient in use.

Are there any experimental data?

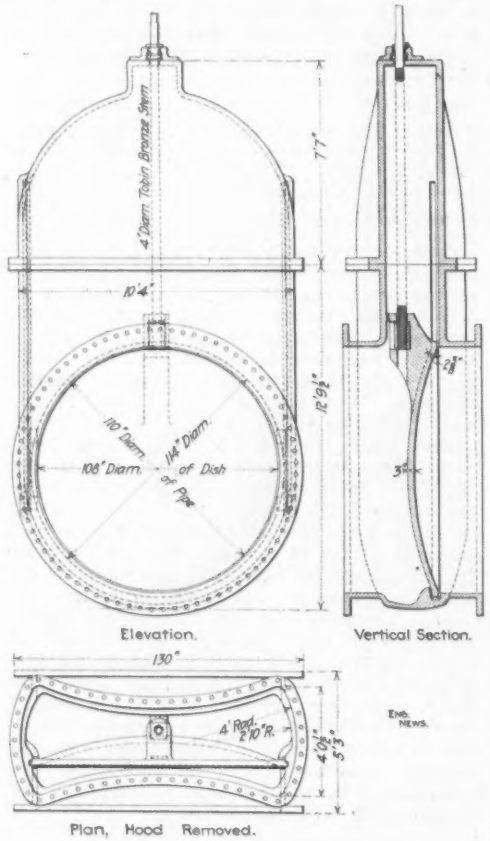
R. Mugnier.

Lamar, Colo., Feb. 22, 1911.

The Design of a Large Valve-Casing.

Sir: I send you the accompanying drawing showing the general outlines of a 110-in. gate valve that I had to design recently. The head of water was 120 ft., giving a pressure of about 55 lbs. per sq. in.

You will notice that to save the metal and reduce the weight of the valve I departed considerably from the generally adopted pattern. The sides of the casing are arched inward so as to be in compression, the water-pressure acting against the convex face. The radii of the inner and outer faces of the side plates are not concentric, but the inside face has the smaller radius, making the metal thicker at the crown (2¾ ins.) than at the ends (2 5/16 ins.). The combined stresses at the corner



Design for a 110-in. Gate-Valve.

are taken care of by reinforcing the corner eccentrically to 4-in. thickness.

You will notice that that shell is strongly reinforced along the full length of the plug guides. The pipe connections are the only reinforcing ribs that I use. The plug itself is of a dished circular shape whose cross-section is in the form of a crescent, 3 ins. thick at the center and 2⅝ ins. thick at the seats. It is provided with six wedges that force it tight against the seat facing, making it watertight.

The stem is of the non-rising type, of Tobin bronze, 4 ins. in diameter, and owing to the guides does not receive any strain except the pull and friction of the plug.

Now, the question has arisen as to the design and strength of this valve. The claim is that it is not as strong as the usual pattern, and is bad engineering. Another claim is that cast-iron in compression will not stand as much as in tension. The opinions of others would be appreciated.

Phil de Clamecy.

Neponset, Mass. March 17, 1911.

[In considering any curved piece under stress, it is important to remember that an arch is an arch only when it has effective abutments. Without abutments it will act only as a beam. To speak of the inwardly-curved side plates of the stem-casing of the above valve as arches would therefore be wrong, since the end plates do not act as abutments to the sideplates; on the contrary, instead of pressing inwardly the end plates pull outwardly on the side plates.

A horizontal slice of the casing has the form of a non-circular ring. This ring is subjected to uniform outward pressure. A true circle is an exact equilibrium figure for such pressure. A non-circular ring experiences bending, roughly in proportion to its eccentricity, if we may use this term when referring to a figure other than an ellipse. Considering the side plates and end plates separately, it is obvious that each will act as a constrained beam, with outward bending at the center and reverse bending at the ends. Thus the corners of the ring are subjected to a severe bending moment, with tension on the inner face. The reverse bending in the side plates near the corner may be great enough to exceed the maximum load moment of the end plates, in which case the end plate would be bent inward, and the normal region of outward bending near the middle of the end plate would disappear. This condition would show four inflection points in the entire ring, while under other conditions there would be eight points of inflection. The location of the inflection points, and therefrom the amount of the bending stresses at the different points of the ring, must be determined by elastic analysis.

We are not able to see that the bending stresses are in any way reduced by the inward curving of the side plates. The shape shown could not show greatly different stresses from those of a flat side-plate of corresponding thicknesses, though the corner moment is probably reduced slightly by the fact that the side plate is longer and hence more flexible when curved as shown

Possibly some of our readers may know of simple methods for estimating the stresses in such a ring.

As concerns the relative tensile and compressive strengths of cast-iron, we suppose it to be generally accepted that good cast-iron is to be credited with about three times as great a utilizable strength in compression as in tension.—Ed.]

The Meaning of "To Tote."

Sir: Referring to your issue of March 30, 1911, p. 390, in regard to the phrase "to tote," to which Mr. D. M. Andrews takes exception:

The word "tote" has different meanings in different sections of the country. In the South, as you state, it means to carry by person. In the Lake Superior lumber district, the road leading to the logging camp is called "the tote road." The wagon that hauls supplies to the camp is called "the tote wagon," but not the sled or wagon that hauls the logs. In the Brooklyn sugar refineries, teams to double-head the loaded trucks up the incline to the new Manhattan Bridge, are called by teamsters "tow teams," which is easily confused with "tote teams." Hence it will be recognized that the word "tow," when used in combination with team, might easily be confused by colored people "to tote," which is now slang for to carry by person.

John Francis.

P. O. Box 609, Birmingham, Ala., April 5, 1911.

What is the Life of Steel Intake Pipes?

Sir: We are contemplating the installation of a 36-in. or 42-in. water-supply intake pipe about 2,000 ft. long. We understand that a great many of these submerged intake pipes are made of sheet steel. We have been unable to obtain any very definite information as to the life of steel pipes when submerged in water and would like to have you give us as much data on this subject as is possible. We have corresponded with engineers of the various water departments of cities along the Lakes and have received very conflicting replies in regard to the life of steel pipe.

Hammermill Paper Co.

Erie, Pa., April 5, 1911.

[We have published at various times a large amount of information on the corrosion of steel water-supply mains. A paper entitled "Corrosion of the Steel Conduit at Rochester, N. Y." by Richard H. Gaines, published on May 28, 1908, p. 578, will be found of particular interest in connection with the above inquiry. This 48-in. riveted steel pipe, although not a submerged intake, was in many cases laid in soil saturated with water. Comparatively little concerning steel intake pipes in general use on the Great Lakes has been published. We shall be glad to hear from readers who can supply useful data in this field.—Ed.]

Table of Deflection Angles for Varying Radii and Chords.

Sir: As so many requests have come to me to explain, by a detailed application, for any radius and any desired chord length, the table of curve data covering ratios 1/200 to 30/200, inclusive, published in Engineering News, April 23, 1908, p. 464, I wish to submit the following table for general use in laying out simple curves. These data give an easy and accurate method for quick application in the field, as the table of unit angles is perfectly general and can be used to cover all radii and all chords. The only thing required is to know the desired length of radius and chord and their ratio.

DEFLECTION ANGLES FOR CURVES
(Constant for all radii.)

R	Δ	δ
100c	0°—34′—22.66″	0°—17′—11.33″
75c	0°—45′—30.22″	0°—22′—55.11″
66.67c	0°—51′—34.00″	0°—25′—47.00″
50c	1°—08′—45.36″	0°—34′—22.68″
33.33c	1°—43′—08.18″	0°—51′—34.09″
25c	2°—17′—31.14″	1°—08′—45.57″
20c	2°—51′—54.31″	1°—25′—57.16″
16c	3°—34′—53.65″	1°—47′—26.82″
12.50c	4°—35′—05.59″	2°—17′—32.80″
11c	5°—12′—37.81″	2°—36′—18.91″
10.75c	5°—19′—54.35″	2°—39′—57.17″
10.50c	5°—27′—31.68″	2°—43′—45.84″
10.25c	5°—35′—31.38″	2°—47′—45.69″
10.00c	5°—43′—55.08″	2°—51′—57.54″
9.75c	5°—52′—44.65″	2°—56′—22.33″
9.50c	6°—02′—02.12″	3°—01′—01.06″
9.25c	6°—11′—49.77″	3°—05′—54.89″
9.00c	6°—22′—10.12″	3°—11′—05.06″
8.75c	6°—33′—05.97″	3°—16′—32.98″
8.50c	6°—44′—40.47″	3°—22′—20.23″
8.25c	6°—56′—57.13″	3°—28′—28.57″
8.00c	7°—09′—58.73″	3°—34′—59.36″
7.75c	7°—23′—35.31″	3°—41′—56.66″
7.50c	7°—38′—42.39″	3°—49′—21.19″
7.25c	7°—54′—32.92″	3°—57′—16.46″
7.00c	8°—11′—31.52″	4°—05′—45.76″
6.75c	8°—29′—45.77″	4°—14′—52.88″
6.50c	8°—49′—24.43″	4°—24′—42.21″
6.25c	9°—10′—37.67″	4°—35′—18.84″
6.00c	9°—33′—37.39″	4°—46′—48.69″
5.75c	9°—58′—37.50″	4°—59′—18.75″
5.67c	10°—07′—27.11″	5°—03′—43.56″
5.50c	10°—25′—54.54″	5°—12′—57.27″
5.33c	10°—45′—31.55″	5°—22′—45.78″
5.25c	10°—55′—48.17″	5°—27′—54.09″
5.00c	11°—28′—42.03″	5°—44′—21.02″
4.75c	12°—05′—04.77″	6°—02′—32.38″
4.67c	12°—18′—04.67″	6°—09′—02.33″
4.50c	12°—45′—31.47″	6°—22′—45.74″
4.33c	13°—15′—05.84″	6°—37′—32.92″
4.25c	13°—30′—45.56″	6°—45′—22.78″
4.00c	14°—21′—41.44″	7°—10′—50.72″
3.75c	15°—19′—28.24″	7°—39′—44.12″
3.67c	15°—40′—29.86″	7°—50′—14.93″
3.50c	16°—25′—35.11″	8°—12′—47.56″
3.33c	17°—15′—13.88″	8°—37′—36.94″
3.25c	17°—41′—59.16″	8°—50′—59.58″
3.00c	19°—11′—17.29″	9°—35′—38.64″
2.75c	20°—57′—04.90″	10°—28′—32.45″
2.50c	23°—04′—26.10″	11°—32′—13.05″

To illustrate my meaning take the table of "Short-Radius Curves" published in Engineering News, Feb. 6, 1908, p. 149, by Mr. E. W. Hess. In that table there are given five columns headed, respectively; "Radius," "Chord," "Central angle," "Deflection angle," and "Deflection for 1 ft." Below I reproduce the first two of these columns, followed by two columns of ratios prepared by myself.

Radius, ft.	Chord, ft.	Ratio, R =	For c = 1 ft. R =
35	10	3.50c	35c
45	10	4.50c	45c
50	15	3.33c	50c
60	15	4.00c	60c
75	15	5.00c	75c
100	20	5.00c	100c
120	20	6.00c	120c
150	20	7.50c	150c
190	25	7.60c	190c
200	25	8.00c	200c
225	25	9.00c	225c
240	25	9.60c	240c
250	25	10.00c	250c
275	25	11.00c	275c
288	50	5.76c	288c
300	50	6.00c	300c
350	50	7.00c	350c
376	50	7.52c	376c
400	50	8.00c	400c
410	50	8.20c	410c

This table shows us at a glance that R = 80 and c = 10, R = 160 and c = 20, R = 200 and c = 25, R = 400 and c = 50, R = 800 and c = 100, etc., all give R = 80, which gives Δ = 7° 10′, and δ = 3° 35′. The ratio governs the angles, since c = 2R sin ½ Δ = 2R sin δ (see Eng. News, March 26, 1908, p. 347), and therefore Mr. Hess' table has many duplications.

The ratios above expressed cover the radii and chords used in street railway data (see Eng. News, Oct. 27, 1910, p. 456), and give infinite possibilities.

Should we wish any other ratio and the angles true to the nearest minute, we can get them instantly by mere inspection of Table IV., Searle's "Field Engineering" pocketbook, if we but remember the data there shown gives accurate values of R and of Δ where c = 100 ft. Therefore, to get the desired central angle Δ, divide his R by 100 (by inspection) to get the desired ratio and the angle opposite is Δ, ½ of which is the δ you wish—an ever ready method of getting the "deflection for 1 ft."

or for any other chord length. Then $L = \frac{cI}{\Delta}$, or

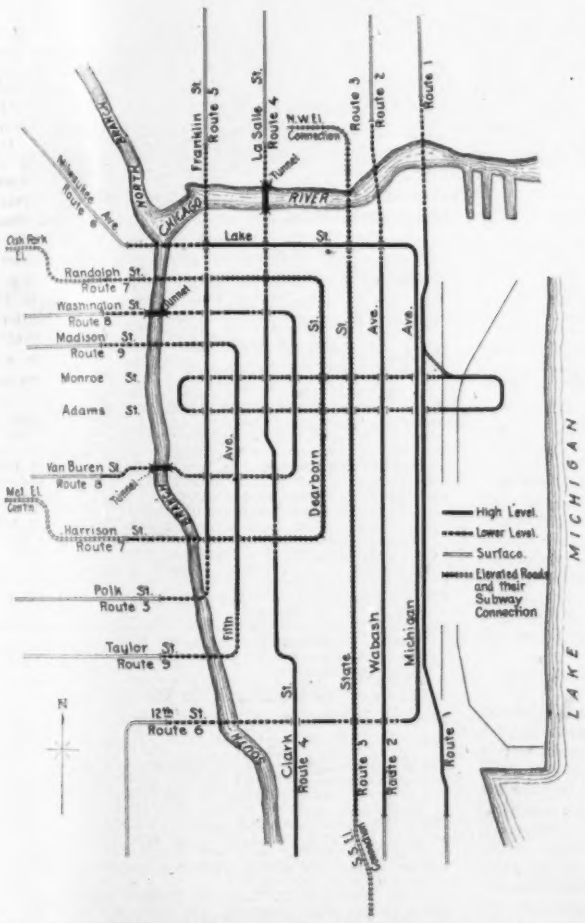
$L = 100 \times 0.0174532925$.

J. Calvin Locke.

200 Montague St., Brooklyn, N. Y., March 24, 1911.

The Proposed Shuttle System of Subways for Chicago.

Sir: In the article on the two suggested plans for subways in Chicago (Engineering News, Feb. 23) the adaptability of the second plan (called the shuttle system by the author) to the use of the elevated roads and to rapid transit, was not shown. On the contrary, the impression is conveyed by the parenthetical expression "for surface cars only," that it is a sort of make-shift and does not provide for this class of service. Instead of this being the case, the simple, direct routing as indicated, employing the minimum amount of curvature, will be most effective in high-speed through traffic, and is the primary object contemplated.



MAP OF BUSINESS DISTRICT OF CHICAGO SHOWING SUBWAY LINES PROPOSED BY A. S. ROBINSON.

An inspection of the accompanying map will show that all of the north and south streets (east of the Chicago River) are occupied by subways; most of the stations are on these streets, and all stations are planned and may be on the upper level. It will be seen also that the movement of the equipment, whether single or in trains of any permissible number of cars, will be entirely through the business peninsula in direct lines without loops, north and south and from and to the west side, in the simplest, most direct manner and with the least amount of curvature.

It has been insisted upon by those most interested in this subject, that the loop feature in any plan tends to concentrate traffic and perpetuate congestion in the business district, and is a serious objection. Hence it is essential that this should be eliminated for through traffic. Another important object accomplished thereby is the reduction of the amount of curvature. With the disabilities of loops and their excessive curvature removed, it is evident that the highest degree of rapid transit can be attained. The only limit will then be on the ability to handle passengers at the stations. When a number of stations are connected, resulting in long loading platforms with numerous commodious entrances and exits, as provided in this plan, the maximum movement of traffic can be accomplished.

The simplicity of the shuttle system, to the lay mind, conveys the impression that it is inadequate for the service that it is intended to perform. But this very simplicity will appeal to the practical man of the profession as one of its chief recommendations. The limits of the paper in which this plan was presented to the Western Society of Engineers necessarily prevented a description of anything more than a mere reference to the features embodied in this system as a whole, leaving the reader to follow out in his own mind the amplification of detail.

The plan to be followed in the construction of the subways outlined in this paper, is as follows: In the first place, two subways (routes Nos. 4 and 8 on the map) utilizing the river tunnels, should be built for the immediate relief of LaSalle, Clark, Washington and Van Buren Sts., by accommodating all their surface lines and such others as would be possible to route through them. As soon thereafter as expedient, a second installation, consisting of another line between the north and south sides and one from and to the west side should be built. Upon the completion of the subways intended for the use of the elevated railways the trains of the latter would be diverted to them, thus providing: (1) Two routes for immediate relief of the surface lines, and (2) two for the use of the elevated roads, all with ample track and platform facilities. With this much of the surface railway traffic and the elevated roads operating through the subways, the surface tracks, and the elevated loop structure downtown, could be abandoned and removed, returning the street surfaces to the use of vehicles.

The further extension of the system, contemplating the occupancy of the other streets, would be built from time to time as traffic conditions demand.

It is evident that the nearer these upper-level single-level subways can be kept to the surface of the streets, the less will be the cost of construction. The stairway distance from the sidewalks to the platforms will be less, and there will be a minimum of excavation interfering with the Illinois Tunnel Co.'s tunnels. On such thoroughfares as Michigan and Wabash Aves., State St., and some other streets, where mezzanine floors would be advantageous in reaching island platforms, there will be room enough between these tubes and the street surface to introduce such floors, since the only deep excavation is at separated grade crossings. As these crossings represent but a small percentage of lower-level excavation, there will be therefore a proportionately larger area where mezzanine stations (if required) can be introduced without disturbing the Illinois Co.'s tunnels. A summation of the features of the shuttle system is as follows:

(1) A comprehensive plan, designed to cover all of the business peninsula with straight-line, high-speed subways, capable of indefinite extension ultimately into the residential districts of the city, and fitting into any proposed plan for Greater Chicago's improvement.

(2) A beginning to be made within the limits of a reasonable expenditure, for immediate relief, with an integral part of the ultimate plan, utilizing the existing river tunnels.

(3) No grade crossings.

(4) Minimum amount of curvature.

(5) Direct through routing.

(6) No loops in the transportation lines, the transfer loop (on Monroe and Adams Sts.) acting only as a transfer.

(7) Shallow excavation, reducing the cost and interference with the Illinois Co.'s tunnels.

(8) All stations on the high level, reducing stairway distance.

(9) Simplicity of routing, on natural lines of travel, assisting in the expansion of the business district.

When it becomes necessary to enlarge the subway area, a simple extension of the routes outward from the business district will accomplish this end. By this means high-speed express service can be added as conditions demand. This enlargement, which however must be provided for, and which would probably be along the lines of the Commercial Club's "Chicago Plan," is more of a future than an immediate undertaking. The problem demanding a solution now is that of designing a comprehensive system of subways through the present congested area, but capable of being extended. With this done, including ample facilities for connecting and routing all of the present outlying street-car lines into these subways as a nucleus, there will result a large surplus of capacity which will be available for future increase of traffic.

A. S. Robinson,
Chief Engineer, Mountain, Valley & Plains Ry.
Dalhart, Tex., March 28, 1911.

[As to the impression given that the system was intended for surface cars only, it should be said that the plans accompanying the paper showed no elevated railway connections. It was stated in the paper that "Chicago's problem is that of building a subway that will accommodate all classes of surface rolling-stock, singly or in train, of the Chicago City Ry. and the Chicago Rys. Co." These two companies operate all the surface lines, and our abstract therefore gave only the same impression as the paper itself. However, the possibility of elevated railway connections was mentioned, and these are shown on the map now submitted. In a later letter Mr. Robinson states that his idea was to illustrate the feasibility of bringing the west side lines (both surface and elevated) into the business district on the upper level, and on the same level with the lines from the north and south side of the city.

The meaning of the "shuttle system" was not well explained in Mr. Robinson's original paper, and was not clear to some of those who discussed the paper. In a written closure to the discussion ("Journal of the Western Society of Engineers," March, 1911), it is explained that it refers to the arrangement of the profile by which some of the lines alternately rise to approach the surface at stations (between the streets) and descend to pass under intersecting subways. This is a substitute for the separate high-level and low-level subways of other plans. The movement is compared to that of a shuttle in weaving. But in railway operation the term "shuttle system" has usually been applied to cases where a single car or train makes a short run to and fro, forming a branch service of a main line or through route.

An objection which was raised to Mr. Robinson's shuttle system was that in some cases undesirably steep grades would be required, but he thought there would be little trouble in this respect.

In stating his objections to the loop system, Mr. Robinson refers to a complete loop by which a car entering at one street passes around a certain section of the business district and returns to the same street for its return trip, as in Mr. Arnold's plan. In Mr. Robinson's plan the loops are three-sided; a car coming in from the west at one street, passes through the business district and returns westward on another street; this was explained in the former article and is shown on the map. The arrangement would be impracticable for the elevated lines, unless the four separate lines agreed to mutual interchange of traffic or were consolidated to form one system. The through routing of the trains of one company over the lines of another has been proposed several times in order to relieve the congestion on the elevated loop, but the companies have refused to make such an arrangement. Consolidation of the elevated lines has been proposed at different times, and it may very likely be carried out by the time a decision has been made as to building a subway system.

As to the local transfer loop (independent of the main subways) under Monroe and Adams Sts., Mr. Robinson states in his closure that he does not consider this feature essential to the success of his system, as most passengers would avail themselves of lines outside the subway area to reach the subway line which would deposit them nearest to their destination.—Ed.]

Some Curious Examples of the Wear of Iron.

Sir: I am sending you herewith a few specimens of metallic scrapings or shavings (reproduced herewith at about one-half original size—Ed.) picked up at a small railway station near New York City. The trains approach this station from the west down a steep grade and have to be heavily braked for the station stop.

These shavings drop when the brake shoes are released, but I am not clear whether they are ground off the wheel or the brakeshoe. The seaweed shaped fragment at the left is as blue as the scrap around an anvil, and the structure of this and other fragments indicate that the metal has been highly heated, and has been torn from the surface of wheel or shoe when in a semi-plastic condition.

It would be interesting to know to what extent the wear of brake shoes and car wheels is due to the detachment of pieces of this size. Apparently such wear must be exceptional or the life of wheels and shoes would be much shorter.

C. W. R.

Arlington, N. J., April 7, 1911.

The Purity and Need for Purification of Lake Waters.

Sir: Mr. Charles B. Burdick's paper in your issue of March 30, 1911, on "The Relation of the Intake Conduit to the Purity of Lake Water" is a good generalization of the subject and no doubt will help a number of lake cities to find the most economical plan for their special conditions.

There is, however, a feature of lake water-supplies taken far from shore that has often, and in the above paper in particular, been overlooked. Mr. Burdick assumes that after a certain distance from shore, lake water is beyond criticism. This is not usually the case and is so recognized with regard to the lakes in Great Britain and in Switzerland.

The entire mass of water in most lakes contains more or less Plankton (low animal and vegetable organisms). Some of these organisms are visible without a microscope and I have found them far out in lakes Michigan, Erie and Ontario. Plankton is not necessarily disease-producing, but is not desirable in table water nor in the kitchen. A rapid filtration with the effect of fine screening is, therefore, used to prevent this trouble, the first time, I believe, being about 20 years ago in Zurich.

There is another feature of long intake-conduit supplies that should be considered. Navigation, even under fairly strict regulations, allows excreta to get into the water. We may, therefore, find in the water typhoid bacilli from convalescents or other walking typhoid carriers on the vessels, and Mr. Burdick says the bacilli may live from three to forty days in pure lake water.

It, therefore, seems that, as in European lakes, we shall eventually be brought to the necessity of filtering all of our lake waters, even when we have an intake pipe extending miles into a lake. But when we get beyond the turbidity belt we can be satisfied with plain, rapid filtration, merely to strain out the Plankton, and with hypochlorite treatment to destroy the pathogenic bacteria, both of which expedients together are generally less expensive than a slow filtration of the roily lake waters.

Rudolph Hering.

170 Broadway, New York City, March 31, 1911.

The Failure of the San Luis Obispo Concrete Oil Tank.

Sir: The excellent description of the failure of the oil tank at San Luis Obispo, Cal., in your issue of March 16, 1911, p. 310, should be the source of some useful lessons to engineers engaged in designing, if engineers were disposed to learn obvious lessons of wrecks.

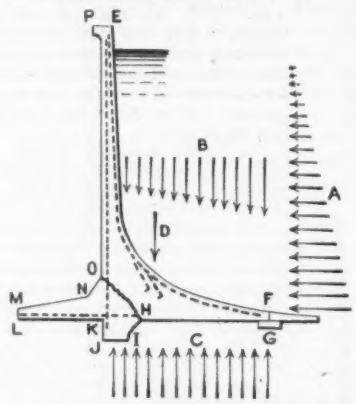
The side of this tank was designed as a retaining wall and not designed for hoop tension. The small amount of circular reinforcement is ample demonstration of this. This reinforcement is small enough to be negligible.

The forces on this retaining wall are easily determined and definite. Liquid pressure admits of exact calculation.

It could scarcely be hoped that the thin floor of this tank could be made proof against leaks. This would be practically impossible. This means that oil was under the floor as well as over it; and the oil under the floor would exert practically the same pressure as that over it, because its escape is purposely made difficult in the design.

The accompanying figure shows the section of this wall and in a general way the forces on it. *A* represents the horizontal force of the oil against the side. *B* represents the pressure downwards on the horizontal portion of the "L." *C* represents the pressure upwards under this "L." *D* represents the weight of the retaining wall. Since *B* and *C* about balance, with a possible upward resultant, it is easily seen that *A* and *D* combined will give a resultant falling outside of the base *K G*. This throws very heavy stress on the little cantilever *L K*. This cantilever is very poorly reinforced. Along the line *O H* there is no reinforcement for the tension of this cantilever. Besides the tension on the surface *O H* there is a heavy shear from the upward reaction of the soil on the surface *L H*. The tendency of the cantilevers *O P* and *O M* is to come together like a pair of shears hinged at *O*, and all there is to resist this (ignoring the loop tension of the entire wall) is the small tensile strength of the concrete on the surface *O H*.

It is very probable that the wall cracked and broke along the line *O H*, just outside of the rods *L H*. This would not disturb any of the main steel reinforcement except to bend over the vertical rods at *O*.



The only remarkable thing about the whole occurrence is the fact that so much oil could be held in the tank even for a little while, but this was probably because it took some time for the ground under the tank to become soaked. However, the tensile strength of the concrete may not have been sufficient to sustain the pressure, even assuming no leaks in the bottom.

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., March 18, 1911.

Sir: Referring to the article in the issue of March 16, p. 310, on the failure of the concrete reservoir at San Luis Obispo, one is struck by the weakness in the design of the wall of the tank.

The intention of the designer was evidently to make the oil on the inner toe of the wall assist in maintaining the wall in an upright position, as earth is frequently made to assist the stability of retaining walls of similar design. But, while earth cannot, by percolating, or seeping under the base, cause an upward pressure, the oil, by doing just that, not only rendered of no avail the oil resting on the toe, but, in addition, reduced the amount of stability of the wall itself by reducing the effective weight of the concrete by the weight of an equal volume of oil.

To ensure against the upward pressure on the base due to percolation or seepage, an effective cut-off, either of wooden sheeting, or of concrete, should have been placed at the point where the inner toe joins the floor of the tank, and no obstruction should have been placed to the free draining off of any oil that might have found its way under the base of the wall. But what do we find in the actual design? No inside cut-off, and a small one placed just where it would ensure an upward pressure having the greatest leverage about the outside toe. The sub-base under the outer toe makes matters still worse.

To show that the conditions as outlined above, were sufficient to overturn the wall, assume the concrete to weigh 145 lbs. per cu. ft., and the oil 55 lbs. per cu. ft. A heavier oil with no viscosity would make matters worse. A simple computation shows that if the full upward pressure is assumed to act from the toe to the wall to the near edge of the cut-off, the overturning moment about the outer toe is 58,000 ft. lbs. against a righting moment of 53,800 ft. lbs. per lin. ft. of wall, for a depth of oil of 18.5 ft. While, if the upward pressure is assumed to act from the toe to the far edge of the cut-off the righting moment is only 35,200 against the overturning moment of 58,000 ft. lbs. per lin. ft.

Under these conditions the circumferential reinforcement would be brought into play; but in a tank of such diameter would be of no avail. The overturning effect would be propagated circumferentially from any one weak spot. Eventually, either all the horizontal rods would be ruptured, and the wall would actually overturn about the outer toe; or, if the foundation is slippery, as wet clay is, rotation would take place around some of the lower circumferential bars until they broke, causing the outer toe to slide or kick back as it slipped along the wet clay.

The remedy, which should be applied even to the structure that has not failed, is to load the inner toe; preferably with rock, if that is available. An embankment thrown up around the outside of the tank would cause the wall to fail in detail, unless the tank is kept full of oil.

Jacob Feuerland.

489 6th Ave., Brooklyn, N. Y., March 21, 1911.

Votes of Confidence for a Municipal Engineer.

At the time of the shirt-waist factory fire in New York City (March 25), where 145 lives were lost, violent attacks were made by a newspaper on the Superintendent of Buildings for the Borough of Manhattan, Mr. R. P. Miller, M. Am. Soc. C. E. The attacks found an easy opportunity because Mr. Miller was then on the Pacific excursion of the American Society of Civil Engineers. Those who know of his work in the Bureau of Buildings for a dozen years past, however, knew that not only were these attacks entirely unfounded but also Mr. Miller has been a chief factor in raising the standard of building administration in New York City.

Professional colleagues have given proper expression to these facts by formal resolutions. The Joint Committee on City Departments, formed of architectural, building, insurance and other interests, on March 30 passed unanimously the following resolution:

RESOLVED: That in the opinion of every member of this committee Mr. Rudolph P. Miller, Superintendent of Buildings, has served the City during his term of office with the greatest possible fidelity; that he is fully qualified for his position and thoroughly competent and conscientious. Furthermore, it is our opinion that the City is fortunate in having him in this important position.

For the New York Chapter, American Institute of Architects: William Emerson, Charles H. Israels, Robert D. Kohn, Burt L. Fenner, Francis H. Kimball, D. Everett Waid.

For the Building Trades Employers' Association: Lewis Harding, C. G. Norman, Ross F. Tucker, George H. Morris, Benjamin D. Traitel.

For the Board of Fire Underwriters: Prof. Ira H. Woolson, F. J. T. Stewart.

For the American Institute of Consulting Engineers: Henry W. Hodge, C. E.; E. W. Stern, C. E.

On the part of the public: George A. Just, C. E.; V. Hugo Koehler, Architect.

The New York Chapter of the American Institute of Architects on April 12 took the following action:

WHEREAS, The New York Chapter, A. I. A., has noted with satisfaction the work of Mr. Rudolph P. Miller in his office of Superintendent of the Bureau of Buildings of Manhattan, and his earnest and intelligent efforts to place the work of this important Bureau upon a high plane of efficiency, not only in the interpretation and enforcement of existing laws, but in his effort to secure revisions of the law where experience has shown revisions to be desirable, therefore

BE IT RESOLVED, That the Chapter record its confidence in his high integrity, his thorough knowledge of the duties of his office, his efficient conduct of its business, and his single-minded devotion to the public interest.

Similar action by the American Society of Civil Engineers would have given added force to the voice of the engineering profession in repelling unwarranted attack on engineers in public service. But unfortunately this society is not so organized as to be capable of extending needed support to its members on occasions like the present.

THE CAMPAIGN AGAINST SPITTING in public places in New York City, carried on under the direction of Health Commissioner Lederle, resulted in 434 arrests during the first three months of 1911. Of the persons arrested, 279 were fined, a total of $414; 44 were discharged, and sentence was suspended in 111 cases.

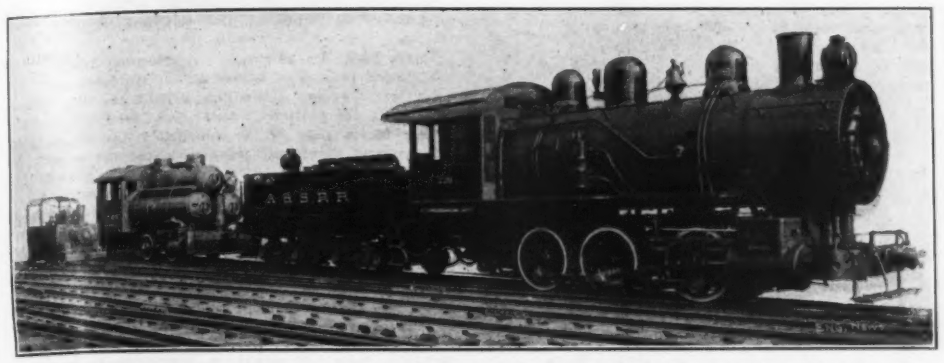
A Contrast in Locomotives.

The accompanying photograph shows three locomotives—all modern, all built by the same maker—and yet presenting a striking contrast in size, design and general appearance. It is an extreme illustration of modification of design due to the different conditions and requirements under which a machine is to be used.

The large steam locomotive (really of only moderate size) is of the six-wheel switcher type with an eight-wheeled tender. Its principal dimensions are as follows:

Cylinders, 20-in. dia., 26-in. stroke; driving wheels, 56-in. dia.; weight of engine, 150,000 lbs.; weight of tender, 140,000 lbs.; rigid wheel base of engine, 11 ft.; height, 14 ft. 6 ins.; width, 9 ft. 10 ins.; length over bumpers, 50 ft. 3 ins.; tractive force, 35,360 lbs.; boiler, straight type; diameter, 72 ins.; pressure, 200 lbs.; firebox, 96 x 39 ins.; 328 tubes, 2 ins. in dia., 11 ft. long; total heating surface, 2,029 sq. ft.; grate area, 26 sq. ft.; tender capacity, 4,500 gals. water, 7 tons coal; standard gage.

Just behind the switch engine is a compressed-air locomotive, which is claimed by the H. K. Porter Co.,* maker of all three engines, to be



A 75-TON SWITCH ENGINE, A LARGE COMPRESSED-AIR LOCOMOTIVE AND A DIMINUTIVE STEAM LOCOMOTIVE FOR PLANTATION USE.

the largest two-stage air locomotive in the world. It was built for use at a powder magazine and is designed to start five loaded freight cars on a level track and to haul two loaded steel coal cars five miles on a single charge of air. It is of the four-wheel type with a main reservoir consisting of three tanks all connected together. The tanks are 40-ins. in diameter, two 15 ft. long and the third 17 ft. in length. The principal dimensions follow:

H.P. cylinder, 11 x 18 ins.; L.P. cylinder, 22 x 18 ins.; wheels, 36-ins. dia.; rigid wheel base, 5 ft. 9 ins.; weight of engine, 55,000 lbs.; capacity, main reservoir, 375 cu. ft.; tractive force, 10,000 lbs.; height, 12 ft. 0 ins.; width, 9 ft. 6 ins.; length, 21 ft. 11 ins.; pressure at throttle, 250 lbs.; L. P. cylinder pressure, 50 lbs.; main reservoir pressure, 825 lbs.; standard gage.

The small locomotive at the left of the picture was built for use on a private plantation railway in Nicaragua. It is of the four-wheel type with side tanks and a steel-canopy cab. Its chief dimensions are as follows:

Cylinders, 5 x 10 ins.; driving wheels, 20-in. diameter; rigid wheel base, 3 ft. 6 ins.; height, 8 ft. 0 ins.; width, 5 ft. 4 ins.; length, 10 ft. 2½ ins.; weight of engine, 11,000 lbs.; tractive force, 1,700 lbs.; boiler, straight type; diameter, 23 ins.; pressure, 160 lbs.; firebox, 26 ins. x 18½ ins.; 37 tubes, 1¼ ins. diam.; 3 ft. 2 ins. long; heating surface, 58.9 sq. ft.; grate area, 3.34 sq. ft.; capacity of tanks, 150 gals.; capacity of fuel box, 200 lbs. coal; gage, 30 ins.

It appears from these data that the plantation locomotive could probably pull the 75-ton switcher along a level track, providing that the switcher were willing.

SEMI-ANNUAL PAYMENT OF TAXES is proposed by the Comptroller of New York City, Hon. William A. Prendergast. Like every other city, New York has to pay its running expenses for salaries to employees, etc., week by week and month by month throughout the year. Its revenues from taxation, however, are practically all payable at one time. The result is that for a considerable part of the year the city has to borrow money to pay its running expenses. On the other hand, for some months after the annual tax payments the city has a large surplus which has to be deposited in banks, giving more or less chance for favoritism and risk of loss. It is proposed to equalize the city's revenue throughout the year by making half the taxes payable on May 1 and half on Nov. 1. The change has been approved by the Committee on Finance and Currency of the New York Chamber of Commerce.

*49th St. and Allegheny Valley Ry., Pittsburg, Pa.

Some Factors in the Success of the Massachusetts Institute of Technology.*

By R. C. MACLAURIN.†

It is fifty years to-day since Governor Andrew signed the charter of the Massachusetts Institute of Technology. Although many enlightened men co-operated in launching the Institute on its course, the enthusiasm and the guiding power were supplied by one man—Rogers. Men of light and leading in the community gave hearty support to the new venture. Governor Banks favored State aid to the Institute on the ground that such an institution would "keep the name of the Commonwealth forever green in the memory of her children." His successor, Governor Andrew, who signed the Institute's charter, was greatly interested and did all that he could to help. "We ought," he said, "to start out on a broad gage and inaugurate a great plan looking to the long future of the Commonwealth." The original faculty of ten professors formed a vigorous group, with great reserve of strength, physical as well as mental. They all lived to a ripe old age, and nearly all earned distinction in their own fields. Four of the men are still happily with us, including the professor of analytical chemistry, Charles W. Eliot, whose vigor is not perceptibly diminished after forty years of exacting toil in the presidency of Harvard.

The charter was granted within a few days of the breaking out of hostilities marking the beginning of the great war. The national crisis, of course, turned men's thoughts away from science and from education. However, after a few years, the nation was ready to turn with undivided mind to the great problems of development. In the quieter field of human activity, the field of thought, the world was experiencing an equally great upheaval. Darwin's great book had just been published, with results of the first magnitude in shaping the lives on which the world of intellect was to move forward for the next half century. Kirchhoff's idea of spectrum analysis was just opening a new era in physics and in astronomy. Faraday was nearing the end of his great career, but his splendid discoveries had not yet borne fruit in the field of practice. His work, however, was having its influence on the mind of Maxwell, the greatest of whose scientific achievements was announced in 1865, the year in which the Institute actually began to work. The world was just entering on a period of remarkable activity in the practical applications of science. The scientists were still struggling with the difficulties of cabling. The Boston of those days was somewhat proud of its critical spirit, and in 1859 a writer in the Boston "Courier" proved at great length that all the so-called messages through the Atlantic cables were fictitious, mere shams to save the stock for a time. Edison, who was living in Boston in 1868, and whose son is an undergraduate at this Institute to-day, was just beginning his wonderful career as an inventor. A few years later, one of the greatest marvels of scientific achievement, the electric transmission of speech, was to be demonstrated in this very city, indeed, in this very hall, by Alexander Graham Bell, through his invention of the telephone.

At such a time, and in such a place, an institution devoted to science and its application had at least an excellent chance of success. The Institute would, however, never have achieved what it has if other forces had not contributed to its success. There is one of the very first importance, rarely, I think, appreciated at its real value, to which special reference should be made. *There has never been any uncertainty or indefiniteness as to what the Institute is aiming at in its scheme of education.*

Every serious student of education is struck by the fact that so many schools and colleges drift around, apparently without compass or rudder, with no definite idea as to what port they are trying to reach, or how they should go to reach it. Here, at any rate, is an institution that, *from the very outset*, has had very definite ideas on these matters, whether those ideas be right or wrong.

Rogers has sometimes been charged with setting up a school in a spirit of antagonism to existing institutions. There is no ground for such a charge. He knew, as every educated man must know, that the fear of what is called *useful* knowledge is exaggerated, and for the most part groundless. He knew, as others do to-day, that the oldest universities all began with a clear recognition of the bearing of their studies on definite callings; and he recognized clearly that it was not a merit, but a defect, of these schools that most of them had failed to keep pace with the changes in the character of human occupations that time had brought forth.

For the guidance of the new school, he laid down a few simple, but far-reaching, principles, which have governed the Institute ever since. The first of these is the *importance of being useful*. There is, of course, no necessary antithesis between the individual and the social end in education. However, the laying of the emphasis is important, and Rogers laid it unhesitatingly on efficiency in the service of society. In his first address to the students at this Institute, he set forth the *value* and *dignity* of the *practical* professions for which they were to prepare themselves. He regarded the scientific habit of thought as specially valuable in practical affairs, and, consequently, in education he laid greater stress on broad principles and their derivation than on details of fact, and he held that the *spirit* of science was more to be desired than all the gold of scientific knowledge. These are his words:

> In the features of the plan here sketched, it will be apparent that the education that we seek to provide, although eminently practical in its aims, has no affinity with that instruction in mere empirical routine which has sometimes been vaunted as the proper education for those who are to engage in industries. We believe, on the contrary, that the most truly practical education, even in an industrial point of view, is one founded on a thorough knowledge of scientific laws and principles, and one which unites with habits of close observation and exact reasoning a *large general cultivation*. We believe that the highest grade of scientific culture would not be too high as a preparation for the labors of the manufacturer.

It will be seen from this that Rogers made no fetish of science, and that he welcomed every really liberal study. Some of the champions of the new school joined in the attack on the older learning; but Rogers had no sympathy with such views. "The recent discussions here and elsewhere," he said, "on the relative value of scientific and classical culture seem to threaten an antagonism which has no proper foundation in experience or philosophy." And although the study of the classics has never formed part of the Institute's courses, history, economics, languages and literature enter into its curricula far more extensively than is generally supposed.

Apart from his appreciation of the value of all sound learning, Rogers saw clearly that the whole controversy as to the relative merits of science and the classics in the field of education missed the mark by placing the emphasis in the wrong place. He understood that when one gets to the root of things in education, the *method* rather than the *subject* is of supreme importance, and his insistence on the value of method in teaching was the cardinal doctrine in his creed and the one that has contributed most to the success of the Institute. The idea is familiar to us all to-day, the idea of *learning by doing*. "How can a man learn to know himself?" asked Goethe. "Never by thinking, but by doing." "The Institute," General Walker was fond of saying, "is not a place for boys to play, but for men to work." Boys and men alike learn most effectively by working for themselves, and the *do-it-yourself* method has been, I believe, the greatest factor in the success of this Institute of Technology.

Whatever be the explanation, there can be no doubt about the fact of its success. It is not merely that the Institute is now the largest institution of its kind in this country, and as regards the extent and variety of its courses and equipment, the most nearly complete in the world. It is not merely that it has grown so that there are a hundred students to-day for every one that took the preliminary course scarcely fifty years ago, and that amongst these students are men drawn by its reputation from the greatest universities of England, France and Germany, as well as from the leading schools and colleges throughout this Union. It is not merely that its teaching staff has expanded so that it contains to-day more than two hundred and fifty men, and that amongst its hundred professors are to be found many men of prominence, and not a few of national and indeed international reputation. It is not merely that amongst its graduates there are men of the front rank as pioneers of knowledge in the field of pure science, nor that its ten thousand alumni have played so great a part in the development of the nation's industry and commerce, and in the preservation of the public health. The most striking fact, when one considers the Institute's youth, is the fact emphasized on an earlier anniversary by Mr. Augustus Lowell and expressed by him in the phrase, "The M. I. T. is *pre-eminently a leader in education*."

*Extracts from the address at the opening of Congress of Technology, Boston, April 10.

†President, Massachusetts Institute of Technology.

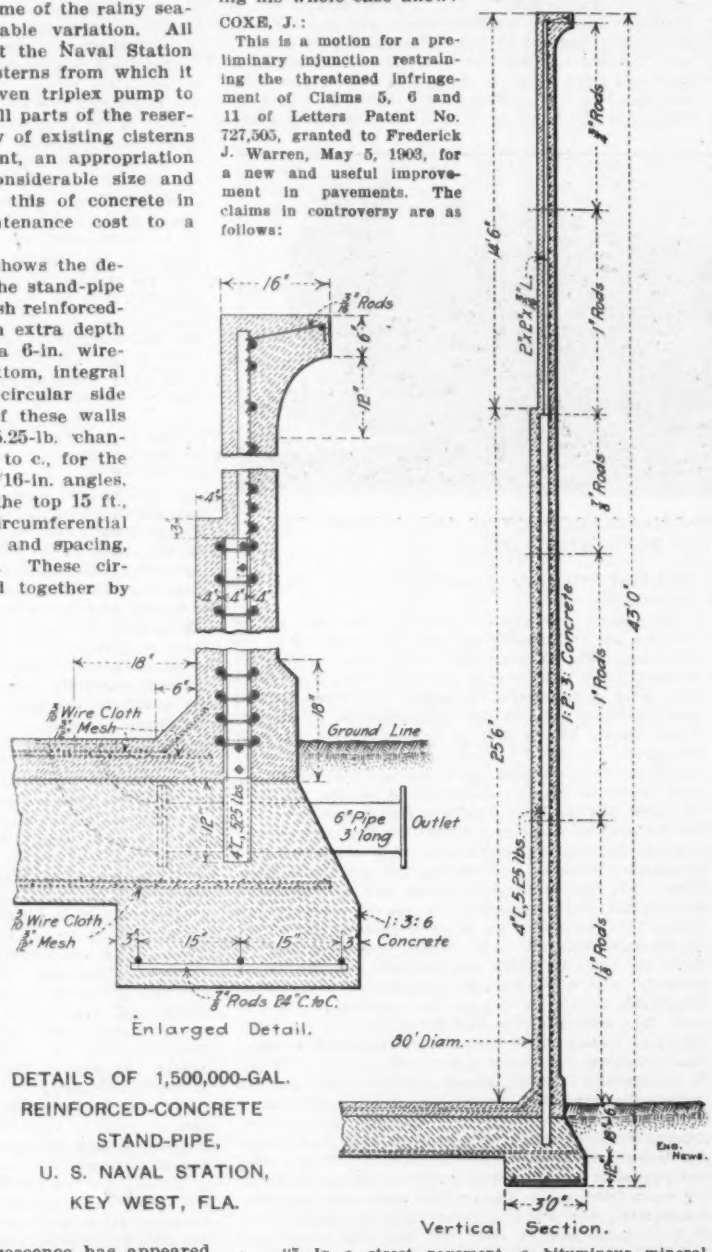
A Reinforced-Concrete Stand-Pipe, U. S. Naval Station, Key West, Fla.

The U. S. Navy Department has recently completed at the naval station at Key West, Fla., a reinforced-concrete cistern or stand-pipe, 80 ft. in outside diameter and 40 ft. high, with a capacity of 1,500,000 gals. All attempts in that city to obtain potable water from wells or deep borings have failed. There are four distilling plants on the island (two of them commercial plants used in connection with ice making) but their limited capacity and the cost of distilling makes it desirable to collect and store as much rain water as possible. The average rainfall is about 45 ins., most of which usually falls in August to December, inclusive, but both the amount of rainfall and the time of the rainy season are subject to considerable variation. All the roofs of the buildings at the Naval Station discharge rain water into cisterns from which it is pumped by a gasoline-driven triplex pump to an elevated tank supplying all parts of the reservation. The storage capacity of existing cisterns not being considered sufficient, an appropriation was obtained for one of considerable size and it was decided to construct this of concrete in order to reduce the maintenance cost to a minimum.

The accompanying figure shows the details of the construction. The stand-pipe consists of an 18-in. wire-mesh reinforced-concrete foundation, with an extra depth under the side walls, and a 6-in. wire-mesh reinforced-concrete bottom, integral in construction with the circular side walls. The reinforcement of these walls consists of vertical 4-in. 5.25-lb. channels, spaced 6 ft. 4⅝ ins. c. to c., for the bottom 25 ft., and 2 × 2 × 5/16-in. angles, with the same spacing for the top 15 ft., bonded together with circumferential round rods of variable size and spacing, as shown on the drawing. These circumferential rods were tied together by special clips, spaced so as to break joints, and were held to the uprights by 1/16-in. wires passed through holes punched for the purpose in the channels and angles.

The base concrete was 1:3:6 and all other 1:2:4 mixture. The specifications provided for bonding of the successive sections, of cistern wall, which were made about 3 ft. in height, by beveled joints and by ½-in. upset end steel dowel pins 12 ins. long and spaced 12 ins. apart. After completion the work was smoothed down and the outside given a brush coat of cement grout. The interior, including the floor, was required to be plastered with three coats of cement mortar after which four coats each of soap and alum washes were to be applied. Some efflorescence has appeared on the outside of the stand-pipe, but no leakage is as yet evident, though on account of drought a full depth test has not yet been available.

The cost of the cistern was $19,950, and of the steel roof, added to the original design, about $5,000. The design was made under the direction of Mr. De Witt C. Webb, M. Am. Soc. C. E., Civil Engineer, U. S. N.



PANAMA CANAL EXCAVATION during the month of March totaled 3,327,443 cu. yds., a daily average of 123,239 cu. yds. for the 27 working days. The month was very dry, only 0.54-in. of rain falling. In addition, 171,477 cu. yds. of concrete was laid and 646,918 cu. yds. of fill placed. The record breaking excavation in the Central Division is given on p. 482 of this issue.

The Warren Patent on Bituminous Macadam Sustained by the Court of Appeals of the Second Circuit.

The decision of Judge Coxe of the United States Circuit Court for the Southern District of New York granting a preliminary injunction against the City of New York and the Uvalde Asphalt Paving Co., which was handed down on Dec. 15 last, has just been sustained by the Court of Appeals, Judges Lacombe, Ward and Noyes. The following is an excerpt from Judge Coxe's opinion. It is of special interest as it bears on the rights of an inventor whose patent is sustained in one circuit to have the protection of the courts against infringers in other districts without trying his whole case anew:

COXE, J.:

This is a motion for a preliminary injunction restraining the threatened infringement of Claims 5, 6 and 11 of Letters Patent No. 727,505, granted to Frederick J. Warren, May 5, 1903, for a new and useful improvement in pavements. The claims in controversy are as follows:

"5. In a street pavement, a bituminous mineral structure, the mineral ingredients of which are mixed and of several grades, so graded as to give the structure an inherent stability.

"6. A bituminous street pavement structure containing mixed mineral ingredients of such grades as to give the structure an inherent stability.

"11. A street paving structure composed of a mixture of mineral or wearing ingredients, and a plastic binder, the space between the mineral ingredients being less than 21% of the whole, and the plastic binder occupying said space."

The Circuit Court of Appeals for the Sixth Circuit in a carefully considered opinion held that the patent was valid and that these claims were infringed. Warren vs. The City of Owosso, 166 Fed. Rep., 306. Thereafter a petition for a writ of certiorari was presented to the Supreme Court of the United States and denied May 24, 1909. The refusal to grant writs of certiorari in patent causes is so general that no important inference can be drawn therefrom. I think it may be said, however, that if the court had entertained the opinion that even a small proportion of the errors pointed out by the defendants existed, the writ would have been granted.

In Warren Bros. vs. The City of Montgomery, 177 Fed. Rep., 414, the Circuit Court for the District of Alabama followed the Owosso decision and sustained the patent.

Whatever view may be entertained as to the obligation of the circuit court of one circuit to follow the decisions of the circuit courts of other circuits, I think there can be no doubt that the doctrine of comity not only but the orderly administration of justice, requires that the circuit courts should adopt and follow the decisions of the circuit courts of appeals of other circuits than their own, rendered upon facts substantially identical. Any other rule would lead to confusion and injustice.

Of course in such circumstances the defendant in patent causes may introduce new evidence of anticipation and may show that the facts on which infringement is based are essentially different from those in the adjudicated case. Such proof must carry conviction with it. It should not avail the defendant if the court be clearly convinced that it is condemned by the reasoning of the decision of the appellate court and would not have changed the result had it been there presented.

This court must, therefore, consider as established the following propositions, which were at issue in the Owosso case:

First. The validity of the patent.

Second. That the patent is not invalid for double patenting.

Third. That the patent is not anticipated by any of the alleged prior uses proved in the Owosso case.

In brief, every proposition decided by the Owosso case, upon substantially similar facts, is *stare decisis*.

This leaves only to be considered the Washington, Chicago and Cincinnati prior uses and the question of infringement.

* * * * * * * *

I have examined the affidavits and the specimens taken by both sides from the Washington pavements and am confident that the testimony does not establish anticipation beyond a reasonable doubt. Some of the specimens produced by the defendants have a general resemblance to the patented composition. Others, taken by the complainant from the same locality, have no resemblance to the particular features upon which patentability rests. It would, in my judgment, be setting a dangerous precedent to overthrow a patent which has been sustained by a circuit court of appeals upon an alleged prior use, supported only by the controverted statements of affidavits. The presumption is against the existence of such a prior use and it should be supported by clear and cogent testimony, which has stood the test of cross examination. It cannot be accepted if contradicted by proof of equal weight. It is not necessary that the court should reject such proof altogether; it is enough that there is doubt about it.

The fact that the samples furnished differ so materially in structure and appearance seems to indicate that the influence of heat and cold and the use of the streets for heavy traffic during long periods of time have worked changes in these pavements, so that their present structure is not what it was when originally laid.

Upon the question of infringement no especial equities exist in favor of the defendants. They both had full knowledge of the Warren Patent. Indeed, a contract was made in July, 1910, with the Uvalde Co. to lay a pavement in the Borough of Richmond. Suit was commenced and a motion for a preliminary injunction was made, but before the motion was argued an agreement was made between the defendants by which the contract was cancelled. The suit thereafter was discontinued. The only inference which can be drawn from this action of the defendants is that they were convinced that the specifications of the first contract, if carried out, would result in an infringement of the Warren patent. Within a few weeks after the first suit was settled by the cancellation of the contract a new agreement, with specifications changed in certain respects, was entered into and this suit was commenced to restrain the defendants from proceeding under the new specifications. The complainant contends that the new contract is but a cunningly devised plan to avoid the patent; the defendants, on the contrary, assert that it was the result of a bona fide effort to settle the controversy by the adoption of a pavement which would not infringe.

The claims in issue are for a product, not a process. The specifications here in question provide that the trap rock used shall be very hard and "it shall be the run of the crusher, passing through a screen with a one-inch mesh; the sand shall be hard grained, clean and sharp and shall all pass through a ten (10) mesh screen."

The principal question is whether stone thus treated will produce the Warren structure. Stated more definitely, the question is whether the patented pavement can be produced by the ordinary "crusher run." But for this limitation, the second specifications are substantially identical with the first, which were canceled. In the first the proportions were 8½ parts of stone, 3 of sand and one of cement; in the second they are 9 stone, 3 sand and one cement. In both the parts are to be mixed until they become "a uniform bituminous con-

crete. The product of the crusher varies according to the character of the stone, the adjustment of the crusher and whether it be a jaw or gyratory crusher. In the present instance, however, the particles of stone must pass through a screen "with a one-inch mesh," and consequently the largest pieces must be less than an inch and vary from the maximum down to the smallest pieces.

On the part of the defendants a large number of experts of high standing and ability state that the use of the stone as it comes from the crusher without screening, sifting or selecting, takes the proposed pavement out of the claim of the Warren patent. In their opinion it is impossible and "simply absurd" to suppose that a pavement laid under the present specifications will infringe the Warren claims. But this is all matter of opinion, where something more than opinion is required. The defendants should show the court the pavement which they propose to lay. It does not materially aid the investigation to show what they do not propose to lay. The complainant has produced exhibits in which the crusher run was used, which seem to conform to the structure of the patent.

The record could have been reduced to one-half its present size if a sample of the pavement proposed to be laid had been produced in court. As it is said that thousands of yards have been laid in Washington and elsewhere under specifications substantially similar to those in the case at bar, it would seem that the production of such a sample would not have been difficult. Where demonstration is possible I dislike to decide so important a question as is here involved, upon the opinion of experts.

My conclusion is that the motion should be granted on a day to be named in the order, unless in the meantime the defendants produce a sample of the proposed pavement with proof briefly stating how it was constructed.

The Court of Appeals' decision sustains Judge Coxe in every particular and affirms his order for a preliminary injunction. From the above quoted opinion, therefore, it would appear that a macadam pavement made by mixing the run of the crusher with bituminous material of the character set forth in Warren's specification will infringe the Warren patent.

Coroner's Jury Report on the Harris & Blanck Shirt-Waist Factory Fire.

As previously noted, the coroner's investigation of the fatal fire in the 8th, 9th and 10th stories of the Asch Building, Greene St. and Washington Place, New York City, was conducted by an unusually able jury, on which were architects, civil engineers and builders. The jury rendered its verdict on April 17, 1911. Besides stating the essential facts ascertained as to the relation of the factory arrangements to the fire, the verdict suggests certain definite lines of improvement in public administration of safety matters. The text follows:

We find that the said Mary Herman came to her death on the 25th day of March, 1911, at the premises 27 and 29 Washington Place by asphyxiation by smoke, caused by a conflagration that originated on the eighth floor, spreading to the ninth and tenth floors in a manner unknown to the jury, and that the body of the deceased was found on the ninth floor of said premises close to the doorway leading to the stairs on the Washington Place side, which door, according to the evidence presented to the jury, was found to be locked at the time of and during said conflagration.

We find that the deceased attempted to escape by said door and that her failure so to escape was due to the fact that said door was locked.

We find that Isaac Harris and Max Blanck, doing business under the firm name of the Triangle Waist Co., are responsible for the death of the deceased because of their criminal negligence in failing to observe the required legal precautions by leaving said door unlocked.

Legislation cannot eliminate all loss of life by fire or by panic, but properly enforced laws can certainly lessen the loss of life from these causes. The evidence submitted to this jury shows that there were employed on the eighth, ninth and tenth floors of said premises about 500 persons, of whom about 80% were females and of whom about 235 were employed on the ninth floor, where nearly all the loss of life by smoke and flames occurred.

We are convinced by the evidence that not only had no attention been given to and no means provided for the hasty exit of those employed in said premises, but on the contrary their safety had been utterly disregarded.

We find that one of the tables to which the machines were attached at which the employees worked was 76 ft. long, that it extended from within 13¼ ins. of the front wall at one end to within 16 ins. of a partition at the other end, thus leaving only two passageways, one of about 13¼ ins. and one of 16 ins., through which said employees were obliged to pass to reach the stairs and elevators.

The foregoing is a condition that certainly should not obtain. If there is any law that permits it it should be immediately repealed. If there is no law governing it such a law should at once be enacted which will prohibit such a condition, and the law should be so framed that its enforcement should rest upon one single department of the city government. There should be no divided responsibility.

It is the opinion of this jury that all fire-escapes should be regularly inspected by the Fire Department and when such inspection reveals non-conformity with the law it should be immediately reported in writing to the Bureau of Buildings, which shall at once order the owner of the building on which said fire-escape is installed to have such changes made as to make it comply with the law, and the Bureau of Buildings shall have power to enforce such order.

Recommendations:

1. That where plans are filed with the Bureau of Buildings for a new building, the application set forth for what purpose the building is to be used; that such building shall be used for no other purpose than that stated unless written permission be granted by the Superintendent of Buildings, who shall issue such a permit only when the building complies in construction with the law governing the class of buildings devoted to this other use.
2. That before any building shall be used plans shall be filed with the Bureau of Buildings showing the location of machinery, tables, exits, etc., together with the number of prospective employees, and that such plans must be approved by the Superintendent of Buildings, who must first determine that the exits will enable all employees to escape in time of emergency.
3. That a compulsory fire drill shall be established where large numbers of employees are assembled.
4. That all factory buildings shall be inspected at least once in six months.
5. That automatic sprinklers shall be installed.
6. That all factory stairways shall be hereafter extended to the roof.
7. That rules shall be posted in large factories telling what to do in case of fire.
8. That an axe shall be placed at all doors of manufacturing places.

Notes from Engineering Schools.

UNIVERSITY OF ILLINOIS.—Two electric iron furnaces have recently been installed at the University of Illinois, through the combined efforts of the Department of Electrical Engineering, the Engineering Experiment Station and the Department of Chemistry. One furnace is a Hoskins resistance type and the other a Colby induction; both are of 20-KW. capacity. These furnaces will be used for studying the changes that can be brought about in the mechanical and physical characteristics of cast-iron through the influence of the "soaking" process which it is possible to employ.

HARVARD UNIVERSITY.—A Bureau of Research in Municipal Government is to be established under the direction of W. B. Munro, Professor of Municipal Government, Harvard University. This has been made possible by a gift of $2,500 a year for ten years, offered by Messrs. Frank G. Thomson ('97) and Clarke Thomson ('99), both of Philadelphia. An anonymous gift of $1,000 a year for five years is to be used by the new Bureau of Research for the collection of material relating to national and state government. This particular work will be in charge of Dr. Arthur N. Holcombe, Instructor in Government, Harvard University.

Theobald Smith, Professor of Comparative Pathology, Harvard University, has been selected by the German Government as Harvard Visiting Professor at the University of Berlin during the second half of the academic year 1911-12.

THE SPILLING OF MOLTEN STEEL at the open-hearth furnace of plant No. 3 of the Midvale Steel Works, Philadelphia, Pa., April 16, killed six men and injured several others.

THE SPANISH STEAMER "SAN FERNANDO" sank April 17 off Finisterre, the westernmost headland of Spain. Twenty-one persons were drowned. The vessel was bound from Huelva, Spain, for Liverpool, England.

NO FATAL PASSENGER TRAIN ACCIDENTS during the past three years is the record of the Vandalia R. R. The report of this road to the Interstate Commerce Commission shows that it carried 9,800,030 passengers in 1908, 1909 and 1910 and that not one of them was killed in a train accident. The average distance traveled by passengers was about 34 miles, the total number of passenger-miles being 330,348,935. The number of passengers injured during the three years, including even trivial injuries, is given as 67. The Vandalia is a part of the Pennsylvania R. R. system. It operates 923 miles of line, 1,716 miles of track.

AN AEROPLANE FLIGHT was made from London to Paris, without stop, on April 12, by Pierre Prier. The start was made from Hendon, about six miles from the center of London, at 1.37 p. m. On account of fog and squalls, the channel was crossed at a height of about 3,200 ft. The arrival at Issy-les-Moulineaux was made at 5.45 p. m. The trip covered about 200 miles, and was made with a monoplane flyer. This is the first attempt to fly from the British to the French capital, although a flight was completed in the reverse direction in August, 1910. However, on account of various delays, 21 days were necessary for the journey.

Capt. Carron, of the French Army Aviation Corps, fell with an aeroplane flyer from a height of 250 ft., on April 18, at Versailles. The aviator was making a cross-country run when the machine dived and turned over.

A LONG-DISTANCE MOTOR-TRUCK RUN which includes some very rough traveling is being made by a car which started from Denver, Colo., on March 1, for a run to San Francisco and thence to New York. The car is a gasoline motor truck built by the Saurer Motor Car Co., of New York. It has a four-cylinder, 37-HP. engine, with chain drive from a countershaft to the rear axle; the transmission provides four rates of speed. The car has 36-in. front wheels and 42-in. rear wheels with solid rubber tires, the rear wheels being made wide enough for two tires. The tank holds 24 gals. of gasoline, and on good roads the car will run seven miles on one gallon of fuel. The weight of the car in running order is about three tons. The trip is being made to demonstrate the ability of the car to carry a paying load under adverse conditions, and its load of lumber (to assist in crossing creeks and soft spots) and camp equipment weighs about 3½ tons. At one time, with frost coming out of the ground, it was necessary to wait a few days until the mud froze. In spite of mud, snow storms, sand storms and other difficulties, the car continued to make progress; it broke through several light bridges and culverts, and in other places had to ford streams. It reached Albuquerque, N. Mex., on April 8. The car is being piloted by Mr. A. L. Westgard, who will report to the U. S. Department of Agriculture on the road conditions encountered.

THE LA SALLE ST. TUNNEL SINKING described in our issue of April 13, p. 461, was accomplished with slighter variation from the exact position than might appear from the description. Our later information is to the effect that the transverse inclination or list gave a difference in level of only 5 ins. at the center lines of the tubes; the larger amount stated in the article would apply to the entire width of the structure (41 ft.). The list was the same at both ends, indicating that there was no twist in the tubes. We are informed also that there was a slight list in the structure when floating. The contractors state that when the structure was originally submerged it was in line and grade throughout, and that the tilting was caused by a slight settlement in the west row of piles. As explained in our article the list is being corrected, so that the structure will be adjusted to its exact position. The methods of handling are considered to have proved quite satisfactory.

MUNICIPAL ELECTRIC LIGHTING PLANTS in the State of New Jersey are made possible by a bill introduced in the Assembly on April 3 by Mr. James P. Mylod, of Glen Ridge. The bill permits any city in the state to establish a municipal electric lighting plant and issue bonds for its construction, provided the bond issue is approved by referendum vote.

A GOOD ROADS BILL passed by the Ohio Legislature makes road dragging compulsory. The trustees of each township are required by the people to appoint in each year a superintendent of road dragging, who receives a salary of $2.50 a day and is to contract for dragging all roads in the township at 50 cts. a mile, the dragging to be done at such times as the trustees direct. A tax levy not exceeding one mill on the dollar is provided for to pay for the road dragging work.

INDUSTRIAL RAILWAYS IN THE UNITED STATES have been investigated by the Bureau of Statistics and Accounts of the Interstate Commerce Commission. There were 2,410 industrial railways investigated. It was found that on June 30, 1909, 202 of these had gone out of business; 1,305 were carried on merely as transportation tools in connection with manufacturing, mining, or lumbering operations, no rates being charged for the freight carried on them; 364 others did some business for others than their owners and derived revenue there-

from. There were 449 others which derived revenue from division of their rates, or from allowances made by railways or other common carriers doing general traffic business.

Personals.

Mr. Daniel E. Moran, M. Am. Soc. C. E., formerly Vice-President of the Foundation Co., New York City, has resigned to enter practice as a consulting engineer with offices at 55 Liberty St., New York City.

Prof. W. K. Hatt, Assoc. M. Am. Soc. C. E., of Purdue University, has been retained by the South Side Track Elevation League of Indianapolis, Ind., to represent its interests in the proposed track elevation in Indianapolis.

Mr. A. E. Harvey, formerly Division Engineer of the Kansas City Southern Ry., at Mena, Ark., has been appointed Chief Engineer of the Metropolitan Street Ry. of Kansas City, Mo. Mr. S. S. Morton has been appointed Division Engineer of the Kansas City Southern Ry. succeeding Mr. Harvey.

Mr. George J. Mack, Jun. Am. Soc. M. E., formerly Mechanical Engineer with the Public Service Commission, Second District, of New York State, has been appointed Inspector of Locomotive Boilers at a salary of $3,000 per annum. He succeeds Mr. G. P. Robinson, who was recently appointed to a similar position with the U. S. Government.

Mr. Leonard C. L. Smith, M. Am. Soc. C. E., who was removed from his position as Consulting Engineer of the Borough of Queens, New York City, as noted in our issue of April 21, 1910, has been reinstated with a year's back salary. Mr. Smith was charged with giving an extension of time to certain contractors on public works of which he was in charge.

Mr. Horace G. Burt, former President of the Union Pacific R. R. and at one time Chief Engineer of the Chicago & Northwestern Ry., has been selected by an association of the leading commercial bodies of Chicago, Ill., to be Chief Engineer for a committee of that association for the investigation of the necessity of electrification of the railways entering the city.

Messrs. Milo D. Burke and William M. Venable, M's. Am. Soc. C. E., have formed a partnership under the firm name of Burke & Venable, consulting engineers, with offices in the Second National Bank Bldg., Cincinnati, Ohio, where Mr. Burke has been located for a number of years. Mr. Venable was formerly Manager of the Breakwater Co., Louisville, Ky.

Mr. Charles J. Poetsch, M. Am. Soc. C. E., until recently City Engineer of Milwaukee, Wis., will open an office in that city in the near future for private practice in engineering, giving particular attention to municipal work. Mr. Poetsch has been connected with the city engineer's office of Milwaukee for 33 years, during 12 of which he has held the office of City Engineer.

Mr. Robert Stocker, Naval Constructor with the rank of Commander, has been appointed Construction Officer at the New York Navy Yard, succeeding Mr. William J. Baxter, who has been transferred to the Boston Navy Yard. Mr. Baxter succeeds Mr. George H. Rock, who has been appointed to the place in the membership of the Board of Inspection and Survey made vacant by the transfer of Mr. Stocker.

Mr. George W. Tillson, M. Am. Soc. C. E., Chief Engineer of the Bureau of Highways, Borough of Manhattan, New York City, has been appointed Consulting Engineer of Public Works for the Borough of Brooklyn at a salary of $8,000 per annum. He succeeds Mr. Robert W. Creuzbaur, M. Am. Soc. C. E., who recently resigned. Mr. Tillson has been in service of the city for more than 15 years and is well known as the author of "Street Pavements and Paving Materials."

Mr. Joseph Mesiroff has been appointed City Engineer of Milwaukee, Wis., succeeding Mr. Charles J. Poetsch, M. Am. Soc. C. E. Mr. Mesiroff is a graduate in electrical engineering from the University of Illinois and has been connected with the Milwaukee Electric Railway & Light Co., the National Engineering & Construction Co., and since 1909, President and General Manager of the Western Engineering & Construction Co., of Milwaukee, which has the contract for constructing the new Grand Ave. viaduct.

Mr. R. Walter Creuzbaur, M. Am. Soc. C. E., has tendered his resignation as Consulting Engineer of Public Works for the Borough of Brooklyn, which position he has held for the past five years, and will open an office in New York City for private practice, with special attention to municipal work. Mr. Creuzbaur carries with him a letter of warm appreciation for long and efficient service from the Borough President of Brooklyn.

Mr. Creuzbaur has served as engineer in a number of city departments, beginning with the New Croton Aqueduct construction in 1884, and including the Department of Docks and the former Department of Public Works of New York City. He has supervised contract construction for five different Comptrollers. He also had part in the location and construction of the elevated railroads of New York; in sanitary work at Long Branch, Newport, Nahant, etc.; in the design of bridges, coaling pockets and docks on the West Shore R. R.; and on railroad and hydro-electric works in Central America. He was engineer in charge of construction and afterwards consulting engineer on the Oak Lane Reservoirs for the Philadelphia water-supply during several years. At Borough President Coler's request Mr. Creuzbaur first assembled certain disjointed subway projects and formed them into a through trunk line from Pelham Bay Park, in The Bronx, to Fort Hamilton, in Brooklyn, for extension to Richmond. This plan was approved by the Rapid Transit Commissioners and the Board of Estimate and Apportionment and was named the Triborough Route.

Under Mr. Creuzbaur's direction the engineering departments of Brooklyn were reorganized in 1906, and men of his selection were placed in the offices of Chief Engineer, Engineer of Design and Engineer of Construction, Bureau of Sewers.

Obituary.

Richard H. Williams, formerly Treasurer of the Chicago & Northwestern Ry., died at his home in Mount Vernon, N. Y., on April 12, at the age of 63 years. He entered the railway service as a clerk and was promoted to Cashier, Assistant Treasurer and Treasurer. He leaves a widow and one son.

Wm. B. Ewing, M. Am. Soc. C. E., consulting municipal engineer, died at his home in Chicago on April 8. He had been connected with the design of sewerage and water-supply systems of a number of towns around Chicago. He was a graduate of Cornell University; became a member of the American Society of Civil Engineers in 1889, and of the Western Society of Engineers in 1891. He was 52 years of age.

Norman Philip Curtis, Instructor in Railway Engineering at the University of Wisconsin and Assistant to Prof. W. D. Pence, Chief Engineer of the Wisconsin Railroad Commission, recently committed suicide at Madison, Wis. He was a native of Biloxi, Miss., and graduated from the University of Wisconsin in 1904. Following his graduation he was for a number of years Vice-President of the Philbrick-Courtney-Curtis Co., Contractors and Engineers of Biloxi.

Charles W. Goodyear, a lawyer, lumberman, railway builder and coal operator, died in Buffalo, N. Y., on April 16. He was born in Cortland, N. Y., in 1846. He practiced law in New York State until 1887 when he became Vice-President of the Sinnemahoning Valley R. R. Later he became Vice-President and General Manager of the Buffalo & Susquehanna R. R. He was also extensively interested in the development of timber and coal lands in Pennsylvania, Mississippi and Louisiana. He was President of the New Orleans Great Northern R. R. at the time of his death.

Edward Augustus Moseley, Secretary of the Interstate Commerce Commission since its first organization in 1887, died at his home in Washington, D. C., on April 18. For many years Mr. Moseley had been recognized as an authority on matters relating to measures and appliances designed to provide safety in railway operation. He had a prominent part in securing the passage of the Federal laws on railway safety appliances. For these and other services he had received the thanks of the Commonwealth of Massachusetts, his native state—"for disinterested services in the cause of humanity."

Mr. Moseley was born in Newburyport, Mass., on March 23, 1846. His early education was obtained in his native town. He studied law and was admitted to practice in the courts of Massachusetts, and in 1870 was admitted to the bar of the United States Supreme Court. He served for a number of years as a member of the Massachusetts Legislature and held other public offices. In 1887 he was appointed Secretary of the Interstate Commerce Commission, the 18th of April marking the 24th anniversary of his entrance to that office.

Aside from his work as Secretary of the Interstate Commerce Commission, he served in other important capacities; he was appointed Assistant Recorder of the Anthracite Coal Strike Commission by President Roosevelt. He was the author of a number of books and articles relating to railways, among them, "Arbitration as Applied to Railways and Their Employees." "Safety Appliances on Railroads" and "One Hundred Years of Interstate Commerce." He was a member of the American Economic Association, the American Academy of Political and Social Science, the American Geographical Society and many other societies and clubs.

Engineering Societies.

COMING MEETINGS.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 15-18. Annual meeting at Chattanooga, Tenn. Secy., D. B. Sebastian, 721 La Salle Station, Chicago, Ill.

AMERICAN RAILWAY ASSOCIATION.
May 17. Semi-annual meeting at New York City. Secy., W. F. Allen, 24 Park Pl., New York City.

OHIO SOCIETY OF MECHANICAL STEAM AND ELECTRICAL ENGINEERS.
May 18-19. Annual convention at Youngstown, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 23-25. Annual meeting at New York City. Secy., F. H. Wentworth, 87 Milk St., Boston, Mass.

AIR BRAKE ASSOCIATION.
May 23-26. Annual convention at Chicago, Ill. Secy., F. M. Nellis, 53 State St., Boston, Mass.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 23-26. Annual convention at Pittsburg, Pa. Secy., Richard Moldenke, Watchung, N. J.

INTERNATIONAL MASTER BOILERMAKERS' ASSOCIATION.
May 23-26. Annual convention at Omaha, Neb. Secy., H. D. Vought, 62 Liberty St., New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
May 29-June 2. Annual convention at New York City. Secy., T. C. Martin, 29 West 39th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 30-June 2. Annual convention at Pittsburg, Pa. Secy., Calvin W. Rice, 29 West 39th St., New York City.

AMERICAN WATER WORKS ASSOCIATION.
June 6-10. Annual convention at Rochester, N. Y. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN INSTITUTE OF MINING ENGINEERS.
June 6. Annual convention at Glen Summit Springs Hotel, Luzerne Co., Pa. Secy., Joseph Struthers, 29 West 39th St., New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 13-16. Annual convention at Chattanooga, Tenn. Secy., Charles W. Hunt. 220 West 57th St., New York City.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-16. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 19-21. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 19-23. Annual convention at Boston, Mass. Secy., P. W. Drew, Wisconsin Central Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 21-24. Semi-annual meeting at Chicago, Ill. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 27-29. Annual meeting at Pittsburg, Pa. Secy., H. H. Norris, Cornell University, Ithaca, N. Y.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 27-July 1. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.—At the regular monthly meeting of April 18 at Pittsburg, Pa., Prof. Jos. W. Richards, of Lehigh University, presented a paper entitled "The Electro-Metallurgical Revolution in the Iron and Steel Industry of Norway and Sweden."

NATIONAL ASSOCIATION OF MANUFACTURERS.—The 16th annual convention will be held May 15-17 at the Waldorf-Astoria Hotel, New York City. Preliminary announcements state that one entire day and evening will probably be devoted to the subjects of accident prevention and industrial insurance. Industrial education is included among the other subjects to be discussed. The sessions will be open to the public. The secretary is Geo. S. Boudinot, 30 Church St., New York City.

THE CIVIC FORUM.—An address on "The New Conception of Business and Industrial Efficiency" will be given by Frederick W. Taylor, Past-President, Am. Soc. M. E., in Carnegie Hall, New York City, April 28. Brief addresses will be made by John Golden, President of the United Textile Workers of America, on the attitude of organized labor toward "scientific management," and by Frank B Gilbreth, of New York City, on its practical operation. The Civic Forum is an educational society organized for the discussion of public questions. Mr. Robt. E. Ely, Director, 23 West 44th St., New York City, is in charge of the meeting.

NEW ENGLAND STREET CLEANING CONFERENCE.—The second conference will be held May 17 at Springfield, Mass., under the auspices of the Bureau of Social Research of Rhode Island and the Springfield Board of Trade. The Massachusetts Highways Association is to join in the conference and will hold its own separate meeting on the following day. At the morning session of the conference, three papers will be presented: "Some Lessons to be Learned from European Street Cleaning Methods," Geo. A. Soper, New York City; "Uniform Methods of Accounting in Street Cleaning Work," Ernest Meyer, Washington, D. C.; "The Relation Between Tuberculosis and Street Dust," S. H. Stone and Wallace Hatch. In the afternoon four papers will be read: "Street Oiling and Street Bacteria," Prof. F. P. Gorham, of Brown University; "Dust and Its Prevention," A. H. Blanchard, Providence, R. I.; "Police Regulations in Street Cleaning Work," A. A. Adams, Springfield, Mass., and James H. Sullivan, Boston, Mass.; "Street Cleaning in City Slums," Carol Aronovici, Providence, R. I. In the evening, Mr. F. L. Ford, formerly City Engineer of Hartford, Conn., will give an illustrated lecture on "Civic Art."

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